

**BBC**

**SKY GUIDE: LAST CHANCE TO CATCH COMET 21P**

THE UK'S BIGGEST SELLING  
ASTRONOMY MAGAZINE

# Sky at Night

#161 OCTOBER 2018

## 15 THINGS STARGAZERS SHOULD KNOW

Essential observing advice to help  
you get more out of the night sky

## The Milky Way in WIDESCREEN

See and image 10 of the best  
star fields our Galaxy has to offer



### WATCH THE SKY AT NIGHT

Exploring the science  
of the Sun and its  
threat to Earth



### VIRTUAL PLANETARIUM

Our interactive guide  
to October's night sky  
highlights



### VIDEO INTERVIEW

Apollo engineer Jack  
Clemons remembers the  
iconic lunar missions



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## This month's contributors include...

### Jane Green

Astronomy author



Jane's head must be in a spin after all the research she did for

her article about the rings and spheres of the Solar System. Page 72

### Pete Lawrence

Sky at Night presenter



As well as curating our 17-page Sky Guide as usual (page

49) Pete reveals how to give your astrophotos scientific value. Page 67

### Steve Richards

Equipment expert



Our regular Scope Doctor (page 87) this month also reviews

a quirky tracking mount that quite literally works like clockwork. Page 94

### Jenny Winder

Space writer



Astronauts usually hog the limelight, but Jenny checks out

a book in which NASA's ground control crew are the heroes. Page 102

# Welcome

The best way to start stargazing is simply to start stargazing



Have you ever looked up at the night sky and been captivated by its beauty, only to then become confused as you try to understand more about what you're looking at? If so our feature on page 32

this month is for you: astronomy writer Jamie Carter shares 15 easy concepts that will help you get more out of your stargazing, and hopefully unlock the doors to greater knowledge about our place in the cosmos.

One of Jamie's 15 tips concerns the Milky Way, and on page 40 we have a detailed look at how to capture wide-field pictures of our Galaxy in all its glory. Astrophotographer Will Gater reveals how to develop your skills to take images of its teeming star fields and nebulae with a relatively simple setup.

Of course, exposures of any duration are likely to reveal the glow of light pollution, but Mary McIntyre comes to the rescue on page 83, where she shows you how to remove background glare from your images

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with processing software, thereby bringing out the starry structure of the Milky Way.

As always, there's much more to see in the night sky this month. Turn to page 50 in our Sky Guide for the highlights, including two bright comets. Enjoy the issue!

**Chris Bramley Editor**

**PS** Our next issue goes on sale 24 October

## Sky at Night Lots of ways to enjoy the night sky...



### TELEVISION

Find out what *The Sky at Night* team will be exploring in this month's episode on page 17



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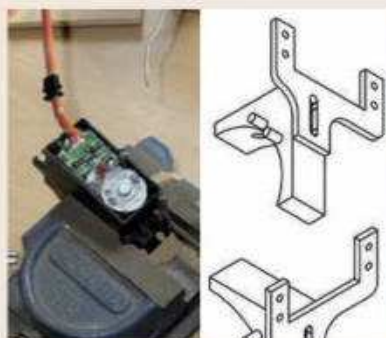
**THERE'S MORE ONLINE**

## October highlights



### INTERVIEW: Remembering Apollo

This month we speak to Apollo engineer Jack Clemons, who worked on some of the programme's most iconic missions. He talks Moon landings, Mars ambitions and Apollo's lasting legacy.



### How to make a battery-free focuser

Use your scope hands-free with our automated gadget. Access images and plans for this DIY project (see p79).



### Watch *The Sky at Night*: 'Death Star'

The team explores the science of the Sun, from the threat of solar storms to the probes being sent to study it up close.



### Download excerpts from astro books

Read samples from new titles including a DK astronomy guide and Maggie Aderin-Pocock's *Book of the Moon*.

## And much more...

- ▷ Hotshots gallery
- ▷ Eye on the sky
- ▷ Extra EQMOD files
- ▷ Binocular tour
- ▷ Equipment review guide
- ▷ Desktop wallpaper
- ▷ Observing forms
- ▷ Deep-sky tour chart



## EVERY MONTH Virtual Planetarium

With Paul Abel and Pete Lawrence

Explore October's night-sky highlights with Paul and Pete



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**YOUR BONUS  
CONTENT**

A gallery of these  
and more stunning  
space images

# Battle amongst the stars

Star-forming regions are unforgiving places where stellar winds can wreak havoc upon the pockets of dust in which new stars emerge

VISTA, 29 AUGUST 2018

The Carina Nebula is one of the largest and most luminous objects in the night sky, although you will not have had a chance to observe it if you've never been to the southern hemisphere. Spanning over 300 lightyears, it is one of the largest star-forming regions in the Milky Way and can even be seen with the naked eye under the right conditions.

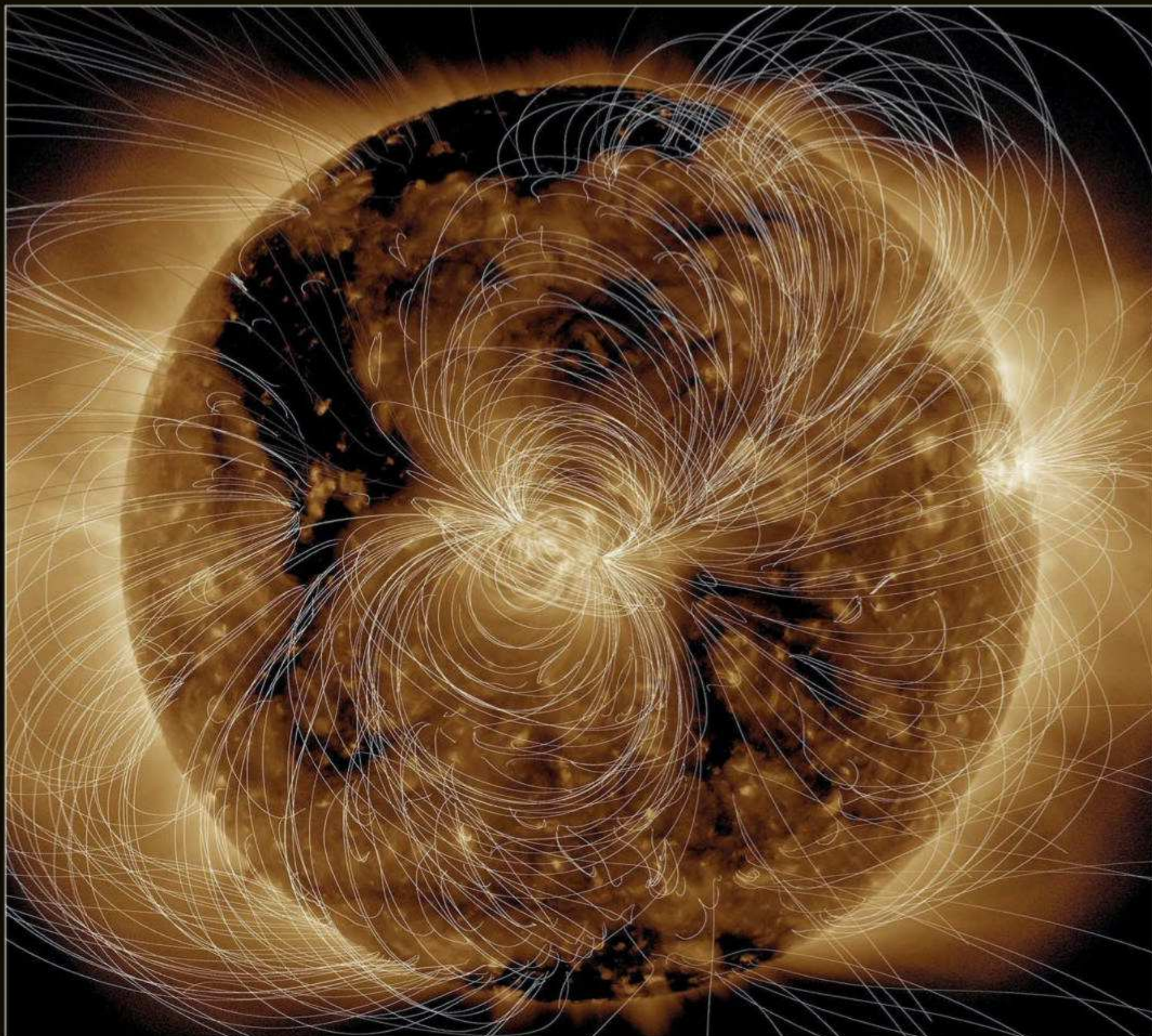
This image of the Carina Nebula was taken at the Paranal Observatory in the Chilean Atacama desert. The VISTA telescope that captured the image has infrared vision, which enables it to see beyond dark dust and gas and get to the heart of this beautiful nebula.

There's something of a battle raging in this region. Star formation is a very energetic and chaotic process, and the stars that form from pockets of dust and gas in the nebula emit intense radiation that causes the surrounding gas to glow. But this radiation can also scorch the dusty regions in which stars are born, vapourising the stellar ingredients and denying future generations the chance to flourish.

ESO/J. EMERSON/M. IRWIN/J. LEWIS







## ▲ Magnetic map

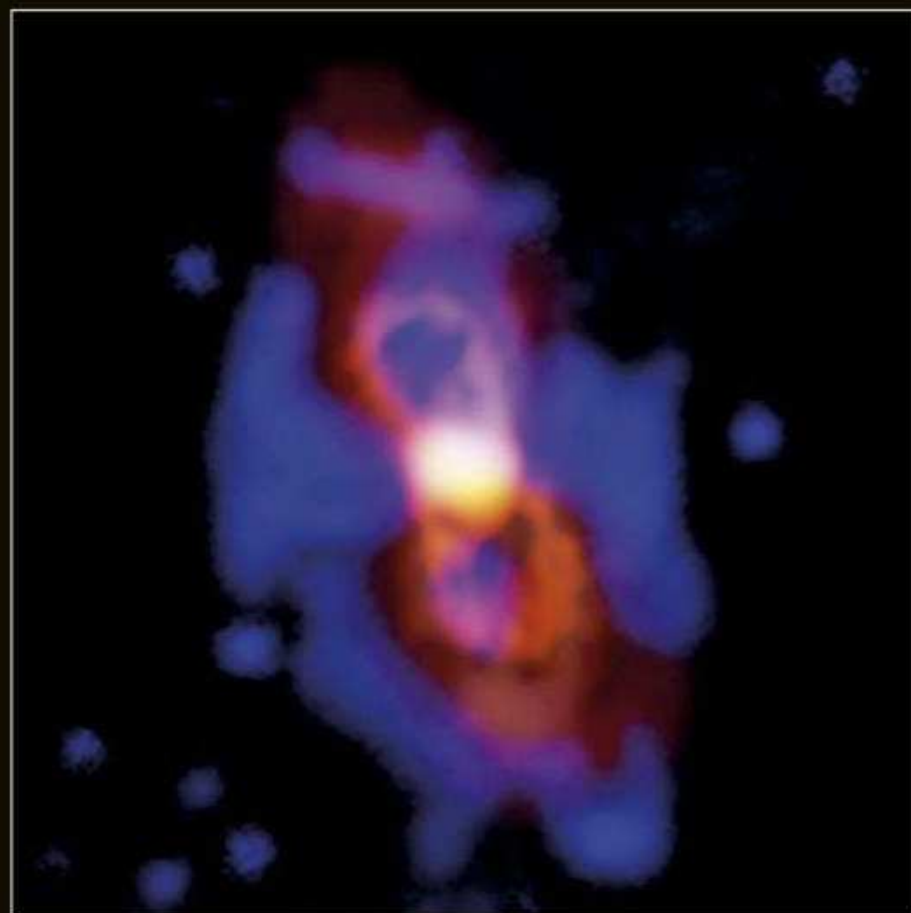
NASA SOLAR DYNAMICS OBSERVATORY, 10 AUGUST 2018

The Sun's magnetic field has a huge effect on our planet. It generates solar flares that can disrupt communications and radio transmissions on Earth, but also produces beautiful aurora displays at the poles. The magnetic field is generated by the movement of plasma, and this NASA image shows a map of its field lines superimposed over an ultraviolet image of the Sun. Note how the field lines are concentrated at the bright, active areas.

## Crash course in cosmic chemistry ►

ATACAMA LARGE MILLIMETER/SUBMILLIMETER ARRAY, GEMINI OBSERVATORY, 30 JULY 2018

This object, known as CK Vulpeculae, is all that remains of a crash between two stars. Here astronomers made the first definitive detection of a radioactive molecule in space; an isotope of aluminium. The detection showed astronomers that molecules forged in the hearts of stars can be flung out into space during stellar collisions.



## The cluster and the cool giant ►

HUBBLE SPACE TELESCOPE, 6 AUGUST 2018

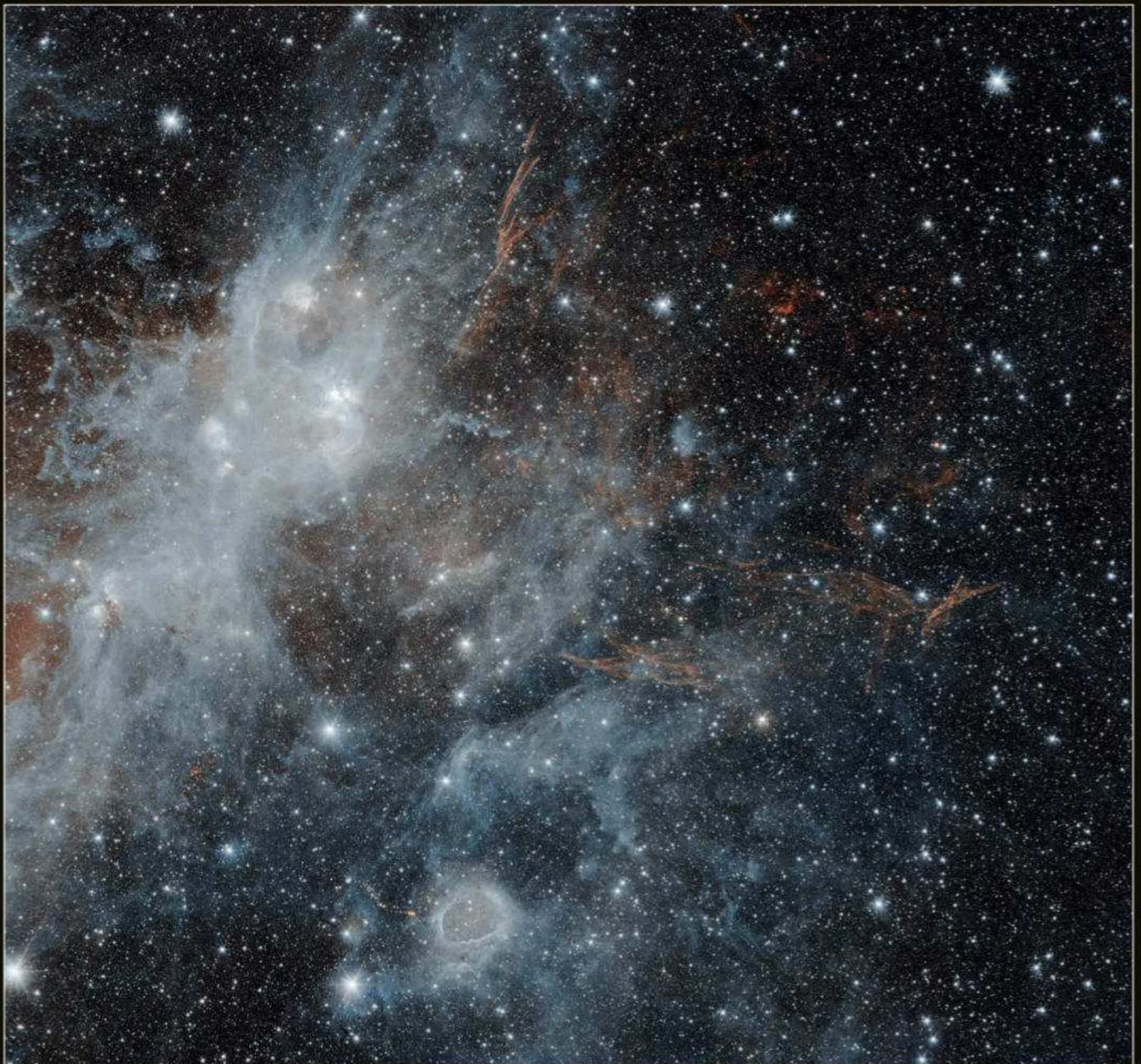
At the right of this image lies NGC 2108, a gravitationally-bound clump of stars known as a globular cluster, which are thought to be among the oldest celestial objects – almost as old as the Universe itself. NGC 2108, however, formed much more recently, about 600 million years ago. To its left is a cool red giant; a type of star with an atmosphere containing more carbon than oxygen, the opposite of our Sun.



## ▼ Remains of a stellar explosion

SPITZER SPACE TELESCOPE, 2 AUGUST 2018

The red tendrils stretching across this image are streams of energised gas left over from an exploded star, known as a supernova remnant. The remnant, named HBH 3, is the cosmic echo of a stellar explosion that may have occurred up to one million years ago, and the red features are likely molecular gas that was hit by a supernova shockwave, causing it to glow in infrared light.



# MUNDO MAYA:

## A GATEWAY TO THE PAST

Mexico is a fascinating and diverse country with many things to offer and showcase, but one of the most important regions to enjoy and get immersed in is Mundo Maya. This area is full of natural wonders, historical remnants, cultural richness, architectural beauty, archaeology, and exquisite gastronomy that make it a world of its own.

We can't begin to explain the region without first talking about the modern Maya people, who are the defining aspect of the Mundo Maya, because they are the descendants of a civilization that spawned 8,000 years ago. They continue to live in the aforementioned Mayan states, standing as the heirs to the past. They are known as "Culturas Vivas" (Living Cultures) because, unlike other Mesoamerican civilizations, such as the Aztec, we can still walk and talk with them, we can taste the recipes of their ancestors, we can walk in their footsteps, wear their garments and understand the importance of preserving their customs. The Maya themselves are a warm society, a living culture of people whose language, dress and food has remained the same for hundreds of years and would happily open their homes and hearts to welcome travelers from around the world. There are many special and uncommon things about this world that make it appealing, and we should now talk about one of the most personal elements: The flavors of the region. The Mayan gastronomy delights palates with the variety and diversity of fresh ingredients and unique cooking methods. Without knowing, the Mayan food might seem strange and foreign, but in reality, the tastes are internationally known and more familiar than you think – like chocolate. This is made from cacao, which was endemic to the culture; they were the first to prepare and make it into the hot liquid we all love and enjoy around the world, today. Chocolate is a great example of how the Mayan culture changed the world. Originally, cacao was used for ceremonial celebrations to honor the gods, and after the Spanish conquest of Mexico, the two cultures merged their ingredients to sweeten the taste.

Of course, the Mayan archaeology and architecture leave a truly lasting impression on all those who visit. The Mundo Maya is known for its most renowned touristic attractions. The one that first comes to everyone's minds is Chichen Itzá. Considered by UNESCO as one of the "New World Wonders", this magical spectacle of mathematical precision, incredible astronomical knowledge and colossal structures embodies the very culture of the Maya.

# CHIAPAS

📍 Lagunas de Montebello, Chiapas

# TABASCO

Cacaco

📍 Chichen Itzá, Yucatán



YUCATÁN

# CAMPECHE



📍 Centro Histórico, Campeche

The mastery of its unexplained engineering feats remains one of the world's greatest mysteries. Today, Chichen Itzá continues to be studied and explored, with new archaeological discoveries still being made.

Mundo Maya offers a diverse array of experiences for people who want to have an immersive adventure, feel the warmth and daring natural resources of the region, and coexist with its sacred animals: the jaguar and the quetzal, considered as intermediaries between the Mayans and their gods. Take a trip to Sian Ka'an, declared as a World Heritage Site by UNESCO. It remains the largest protected area in the Mexican Caribbean and visitors can explore the Boca Paila lagoon and Ascension Bay, spend time with dolphins, sea turtles and an array of species of birds that nest there, and so much more.

The Mundo Maya is the perfect blend of ancient culture and modern luxury, housing all sorts of top-notch experiences if what you're looking for is a time of splendid leisure and wellness. It is the home of some of the most unique golf courses

in the world, it welcomes the most prestigious cruises, and hosts travelers at the fanciest boutique hotels and resorts. This is a region that invites everyone to relax and enjoy the pampering that only our locations and world-renowned service provide. And if you are thinking, how can I visit all of these places in just one trip? The answer is simple: traveling is easy because the region is connected.

Mundo Maya's name implies that it can be explored as thoroughly as you wish if you put your mind to it, everything is closer than you think! It is very easy to begin your day in a jungle then kayak through a mangrove and watch the sunset at the beach. But if you feel one trip is not enough, our wonderful world is always here ready to welcome you back over and over again – because the truth is one trip won't be enough.

Mundo Maya invites you to come and visit all of our wonders, a place where history blends with heritage and a living culture. The question is not if you are interested in coming, the question is...

HOW FAR WILL YOU GO?

# QUINTANA ROO



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# Bulletin

The latest astronomy and space news written by **Elizabeth Pearson**

**PLUS**  
**CUTTING**

**15** CHRIS LINTOTT  
**17** LEWIS DARTNELL

**EDGE**

Our experts examine the hottest new astronomy research papers



## COMMENT

by Chris Lintott

Hidden ice in permanently shadowed craters at the lunar poles! Much of the excitement is that water is the most useful of substances, for drinking and, spilt into hydrogen and oxygen, for rocket fuel. But there are scientific mysteries here too.

Some shadowed, cold craters – such as Amundsen near the South Pole – have all the right conditions but no water. On Mercury and Ceres – two other worlds whose rotation allows for the presence of permanently cold traps – if conditions are right, then ice is found. But that's just not true on the Moon.

What's going on? One explanation is that the observed ice may all be old, the result not of ongoing processes but of events billions of years ago. If astronauts do visit the lunar poles one day, they may be drinking some of the oldest water deposits anywhere; perhaps there's a future business in artisanal lunar mineral water.

CHRIS LINTOTT co-presents *The Sky at Night*



The discovery of water on the Moon could have a significant impact on the future of lunar missions

## Ice confirmed at lunar poles

The find could be mined for water and oxygen by future lunar missions

Water has been confirmed on the surface of the Moon for the first time. Astronomers taking a fresh look at data from the Indian Space Research Organisation's Chandrayaan-1 lunar orbiter found the spectroscopic signature of water around the lunar poles.

A team of scientists made the discovery by re-evaluating observations taken in 2009 by the orbiter's Moon Mineralogy Mapper – a spectrometer which created an atlas of the mineral compounds found across the Moon's surface. This map revealed deposits of water ice concentrated around the lunar craters of the southern pole.

As the Moon is only slightly tilted on its axis, there are some parts of craters that sunlight never reaches. These shadowy corners never rise above  $-150^{\circ}\text{C}$ , meaning the water remains

frozen and does not evaporate or sublime away. There is also ice around the northern pole, but it is more sparsely spread over a wider area.

Several previous observations of the Moon have shown evidence of lunar water. These included a mission where an impactor was crashed into a crater shadow, and water was observed in the ejecta. But it was unclear whether this water was at the surface, underneath it or locked up in rocks.

This latest discovery, though, is within the first few millimetres of lunar regolith making it easily accessible for future lunar missions. Finding water has been a priority for NASA as part of its mission to return astronauts to the Moon, since could be mined for use both as drinking water and a potential source of oxygen.

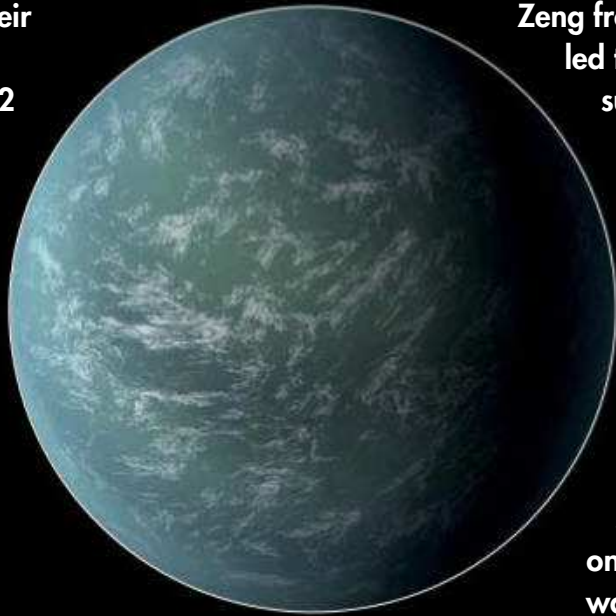
◀ See Comment, left

# Water-worlds are common

Many 'Earth-like' planets could actually be water-worlds, with half their mass made up of water. For comparison, Earth is only 0.02 per cent water by weight.

The revelation came from combining the mass measurements of over 4,000 exoplanet candidates with their latest radii measurements from the Gaia satellite. This showed that planets two and four times the size of Earth could be as much as 50 per cent water.

"Our data indicates that about 35 per cent of all known exoplanets that are bigger



▲ Many Earth-like exoplanets could be half-water by mass, but much of that will be in the form of gas or ice

than Earth should be water-rich," says Li Zeng from Harvard University who led the research. "It was a huge surprise to realise that there must be so many."

However, with surface temperatures up to 500°C, it's unlikely their oceans will be Earth-like. "Their surface may be shrouded in a water vapour-heavy atmosphere, with a liquid water layer underneath," says Zeng. "Moving deeper, one would expect to find this water transforms into high-pressure ice before we reach the solid rocky core."

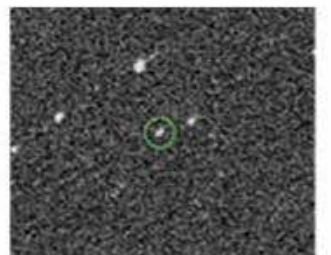
[www.harvard.edu/](http://www.harvard.edu/)

## NEWS IN BRIEF



### ASTRONAUTS FOR INDIA BY 2022

Indian Prime Minister Narendra Modi has announced his nation's commitment to sending an Indian 'vyomnaut' into space using the nation's own technology by 2022. The Indian Space Research Organisation (ISRO) has already designed a crew module and space suit, and tested a crew escape system as part of the country's space ambitions. It's hoped Modi's 'Kennedy moment' will help spur the nation's passion for space, and speed up the project's timeline.



### FIRST IMAGE OF BENNU

NASA's OSIRIS-REx spacecraft has had its first glimpse of its future home, the asteroid Bennu. It took the image from 2.3 million km away as it began its final approach.

"Right now, Bennu looks just like a star, a point source. That will change in November, when we will begin detailed observations and we'll start seeing craters and boulders," says Carl Hergenrother, leader of the working group for OSIRIS-REx. The spacecraft is due to arrive at Bennu on 3 December.

# Early Universe was barren of galaxies

## Surprisingly, the lack of matter made the region harder to see through

One of the most opaque places in the Universe could contain very little matter.

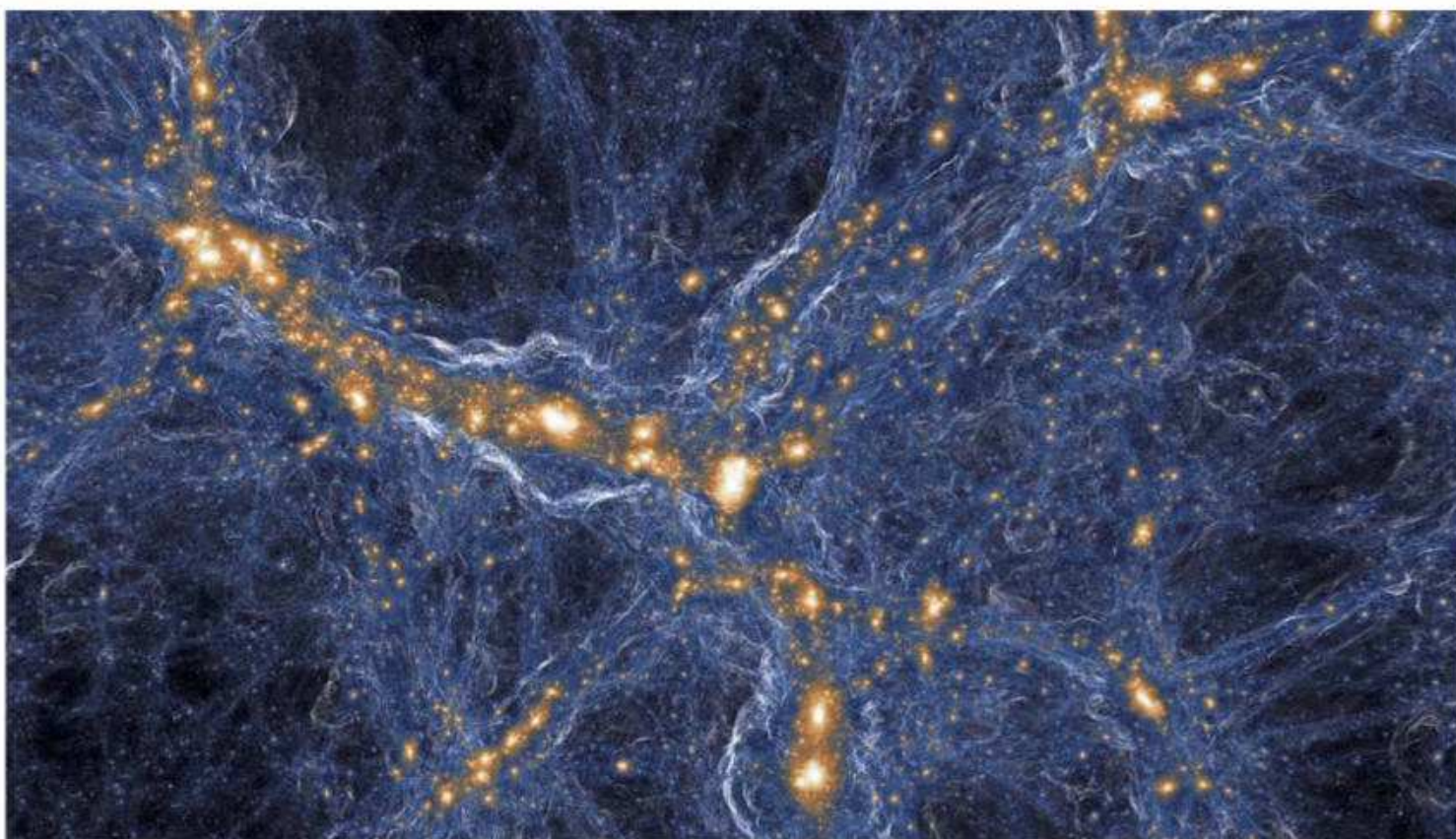
About 12.5 billion years ago the Universe was more opaque and varied than it is today. To learn why, a team of astronomers used the Subaru telescope to observe a particularly opaque 500 million lightyear-wide region of the early Universe.

If the region behaved like the current Universe, the team would expect to find many galaxies filled

with gas, which absorbs light. Instead they found there were very few galaxies.

This discovery might not be as counter-intuitive as it sounds at first. Today, interstellar gas is kept transparent by its interaction with the ultraviolet emitted by starlight. So if there are fewer stars about, they are generating less ultraviolet and the gas would therefore be less transparent.

[subarutelescope.org](http://subarutelescope.org)



▲ Research by Becker's team suggests that early in cosmic history, void regions like the one at the top of this simulation could have been the murkiest places in the Universe despite containing the least amount of dark matter and gas

## NEWS IN BRIEF



### SPACE BADGE FOR BROWNIES

Brownie Guides will now be able to work towards a new Space Badge. To achieve the badge, Brownies will face challenges such as identifying constellations, safely recording sunspots and creating their own astronaut training programme.

"The UK Space Agency is delighted to be working with Girlguiding on this exciting new badge, which will introduce young girls to the wonders of space," says Alice Bunn, international director at the UK Space Agency.



### UK SETS SATELLITE GOALS

On his first visit to the site where a new spaceport is set to be built in Sutherland, British Secretary of State for Business Greg Clark suggested that as many as 2,000 satellites could be launched from the UK by 2030. Currently, small satellites have to 'piggy back' on larger launches, and only 35 per cent of the demand for launches is being met. Picking up the slack could generate as much as £3.8 billion for the UK economy, experts estimate.

THE ROYAL ASTRONOMICAL SOCIETY/UK SPACE AGENCY/GIRLGUIDING, ORBEX, NASA/JPL-CALTECH/VIVIEN PARMENTIER/AIX-MARSEILLE UNIVERSITY (AMU), NASA/JPL-CALTECH



Ultrahot Jupiters have one side that always faces their sun, which is one reason they heat up to such extremes

# ULTRAHOT JUPITERS ACT LIKE STARS

Their atmospheres are intense enough to rip water molecules apart

A pair of recent studies into ultrahot Jupiters have revealed that they are super-heated to the point of acting act like stars, with atmospheres so intensely hot they can tear water molecules apart, and vaporise iron and titanium.

Ultrahot Jupiters are gas giants that are tidally locked to their star, meaning that one side is constantly in daylight. As these worlds are also in a tight orbit, temperatures can reach 4,000°C, which is hotter than many stars.

The spectra of these worlds – which indicate what elements and compounds are in their atmospheres – has confused astronomers for many years. To help understand what's going on in the atmospheres of these odd worlds, one group of researchers recently simulated the atmosphere of ultrahot Jupiter KELT-9b.

"The results of these simulations show that most of the molecules found there should be in atomic form, because the bonds that hold them together are broken by collisions between particles that occur at these extremely high temperatures," says Kevin Heng from The University of Bern, who led the study.

This means that metals would be vaporised by the heat, making them detectable. This was indeed confirmed when astronomers made

follow-up observations of KELT-9b and found titanium and iron in the atmosphere.

Considering the planetary atmosphere to be more like that of a star's than a planet's led another group, headed by Vivien Parmentier from Aix Marseilles University, to uncover a different mystery regarding ultrahot Jupiters.

Astronomers expected them to be rich in water, but instead they appear almost completely arid.

This study found that the extreme heat of the starlit side would tear apart the water molecules in the atmosphere, creating oxygen and hydrogen. However, the dark sides of ultrahot Jupiters are thousands of degrees cooler and the disparity creates powerful winds that carry these elements into an atmosphere that's cold enough for them to reform. As the dark side is constantly in shadow, this can't be confirmed directly through observation, but it could explain why traces of water have been spotted along the terminator between day and night.

"With these studies, we are bringing some of the century-old knowledge gained from studying the astrophysics of stars to the new field of investigating exoplanetary atmospheres," says Parmentier.

[www.unibe.ch/index\\_eng.html](http://www.unibe.ch/index_eng.html)



CUTTING

Our experts examine the  
hottest new research

EDGE

# Globular clusters found on far side of the Galaxy

Until now the stellar clusters have been hidden by dust, and there are likely more to be discovered



Infrared imaging has detected two globular clusters on the far side of the Milky Way that had previously been obscured by dust

This month's research paper takes us to an unexplored corner of our own Galaxy. Our guides are two researchers from Seoul, Jinhyuk Ryu and Myung Gyoon Lee, who have been charting the Milky Way's furthest reaches in search of new clusters of stars. There's a particular problem with finding these in the plane of the Milky Way itself; looking at this part of the sky, the view is blocked by nearby dust that hides more distant objects.

This isn't a new problem. William Herschel's 18th century attempt to work out the shape of the Galaxy was stymied by the effects of dust, which led him to conclude that the Sun lay at the centre of a flat pancake of stars (so he scores well for correctly deducing we live in a flat disc, but less well for placing us at the centre). Modern astronomers, though, have many more advanced tools at their disposal, and in this case the ability to use



**CHRIS LINTOTT** is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project

telescopes and cameras sensitive to the infrared region of the spectrum proved crucial.

The team worked with data obtained by two venerable surveys: UKIDSS (UKIRT Infrared Deep Sky Survey), which made use of the UK InfraRed Telescope – or UKIRT – on Mauna Kea in Hawaii, and 2MASS (the Two Micron All Sky Survey), which used data from telescopes in Arizona and Chile. Carefully combing through the data in the direction of the galactic centre, the researchers found more than 900 new clusters, of which two were possible globular clusters.

Now known as RLGC1 and 2 (Ryu and Lee Globular Cluster), both are just about visible in infrared images as small groups of resolved stars. A careful counting of stars in both systems reveals the hallmark of a globular cluster, a distribution which leads to a greater density of stars toward the centre; it's this that distinguishes a globular from a mere open cluster. They hadn't been spotted before because of their position on the far side of the Milky

"If I had to guess, these clusters are all that remain of two small galaxies cannibalised by the Milky Way as it grew rapidly in the distant past"

Way, and because of their distances: RLGC1 is 93,000 lightyears away and RLGC2 52,000.

Globulars tend to include older stars, and that's true here too; careful measurement suggests both are older than 12 billion years, typical for this type of globular. Both appear to be independent systems, isolated from other clusters and not part of the main body of stars that comprises the Milky Way disc. If I had to guess, these newly-discovered clusters are all that remain of two small galaxies, cannibalised by the Milky Way as it grew rapidly in the distant past. By making sure we have a complete count of these remnants, we can try to understand how that process happened, and why we have the Galaxy that we see today.

The paper ends with an encouraging note for cluster hunters. Of the 214 known Milky Way globulars, 78 lie in or near the disc, but most of those are on the near side. That means there are, the authors reckon, about another 30 to be discovered. Our Milky Way still has plenty of unexplored space with treasures lurking inside.

**CHRIS LINTOTT** was reading... *Discovery of Two New Globular Clusters in the Milky Way* by Jinhyuk Ryu and Myung Gyoon Lee. **Read it online at** [arxiv.org/abs/1808.03455](https://arxiv.org/abs/1808.03455)

## NEWS IN BRIEF



### SUN OBSERVER LAUNCHES

The Parker Solar Probe successfully launched towards the Sun on 12 August. "Now, Parker Solar Probe is operating normally and on its way to begin a seven-year mission of extreme science," said Andy Driesman of Johns Hopkins University and project manager of Parker. The spacecraft will perform the first of seven Venus flybys on 3 October. This encounter will nudge the craft into an orbit that takes it through its first perihelion on 5 November.



### STEVE'S NOT AN AURORA

A steak of purple light once thought to be an aurora – nicknamed STEVE – might not be auroral after all. STEVE events were first spotted by aurora hunters, and are only now being investigated by atmospheric scientists. They re-evaluated data from a STEVE event in 2008, searching for signs of charged particles raining down on the ionosphere, indicating an aurora event. None were found, suggesting a different, as yet unknown, phenomenon is at play.

NASA/BILL INGALLS, RYAN SAUT/ALAMY STOCK PHOTO, NASA X 2, © K.H. JOY

## Air leak on ISS is plugged by a finger

Investigators think the hole was caused by a human hand

The International Space Station has sprung a leak. Flight controllers first noticed a drop in air pressure on 29 August. The station's crew spent a day isolating each section of the station to hunt down the source of the leak. They eventually found a 2mm hole in one of the Russian Soyuz capsules, docked to the station since June. The rupture appears to have been caused by a manufacturing fault.

In the proud astronaut tradition of making do with what's on hand, ESA astronaut Alexander Gerst initially plugged the hole with his finger, making him the first person to ever come into direct contact with the vacuum of space. He later covered the hole with duct tape before the Russian crew patched the hole with a sealant covered cloth. At the time of writing, engineers are trying to find both the cause and a solution to the leak.

[www.nasa.gov](http://www.nasa.gov)



▲ Duct tape and an astronaut's finger formed the first line of defence when the ISS sprung a leak

## Early Solar System had organics

Organic matter, one of the key ingredients for creating life, formed in the early stages of our Solar System. Planetary geologists found key elements needed for life in recent studies of carbonaceous chondrite meteorites – former space rocks that have not been altered since the Solar System began to form.

"Chondrites are a snapshot of the early Solar System, providing key insights into how protoplanets and planets formed and were processed," says Romain Tartèse from the University of Manchester, who led the study. If such compounds were created in the infant Solar System, it is likely that they formed in other planetary systems, meaning that other planets could have the ingredients needed for life.

[www.manchester.ac.uk](http://www.manchester.ac.uk)



▲ Chondrites are like stony time capsules – meteorites formed from material present in the early Solar System

## LOOKING BACK THE SKY AT NIGHT

### 13 October 1967

In 13 October 1967's episode of *The Sky at Night*, Patrick discussed the Lunar Orbiter programme. From 1966-67, NASA sent five spacecraft to survey the Moon's surface in anticipation of the Apollo landings.

The first mission launched towards the Moon on 10 August 1966, where it hunted out potential landing sites for the Apollo missions. Two weeks into its mission the spacecraft took time out to take the first

photograph of Earth rising up over the lunar horizon. While the first three Lunar Orbiters were focused around the latitudes the Apollo programme was concerned with, the final two imaged the rest of the lunar surface. Between them, the five missions managed to map nearly 99 per cent of both the Moon's near and far side.

Once their missions were complete, the orbiters were crashed into the Moon to prevent them threatening future lunar missions.



▲ The first ever photo of Earth from the Moon, taken by Lunar Orbiter 1

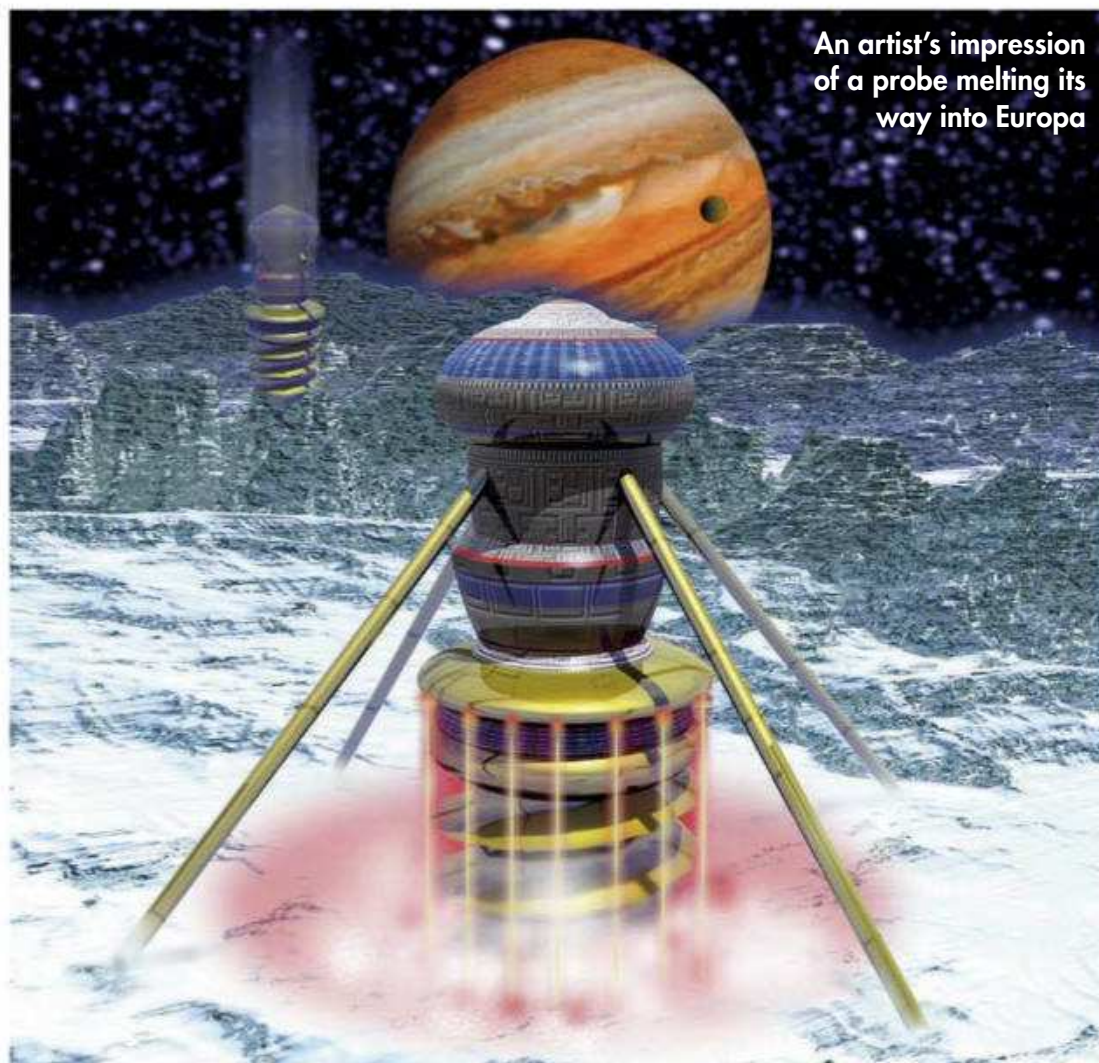
## CUTTING

Our experts examine the hottest new research

## EDGE

## How to build an ice-diving probe that won't freeze up

Rather than boring through rock-hard ice, future robotic explorers to ice worlds will melt their way in



An artist's impression of a probe melting its way into Europa

Some of the most intriguing objects in the Solar System are ice worlds. The moons Europa and Enceladus are hiding large bodies of liquid water deep under their surfaces, sealed beneath a shell of hard-frozen ice. Liquid water is thought to be one of the fundamental requirements for supporting life, and so many planetary scientists are very keen to explore these alien oceans.

The challenge, though, will be penetrating down through a substantial thickness of rock-hard ice to access these exciting environments. On Earth, this sort of operation (like drilling down into Lake Vostok buried deep beneath the Antarctic ice) is accomplished with huge, industrial machinery and a team of human engineers to maintain it: a mission using a setup of this type is simply not feasible in the near-term of space exploration.

So how will we be able to reach the interior of these icy worlds with current robotic technology? The most

promising solution is a melter probe. A roughly cylindrical canister holds a suite of scientific instruments, and sports a heated plate at the front to slowly melt its way down.

But there remain a number of engineering problems that need to be solved, say Kai Schüller and Julia Kowalski from RWTH Aachen University in Germany. For one, the probe needs to melt the ice immediately beneath it, whilst ensuring that it doesn't refreeze too quickly in the channel that's been created and trap the probe. While designs can be tested on Earth, the much colder ice and lower gravity of the icy moons would slow the downwards progression of the probe and so increase the risk of such a lock-in.

Schüller and Kowalski have been studying how to make the most efficient use of the heating power a small probe could deliver and ensure it doesn't become stuck. They've modelled a simple design to see how parameters like the length of the probe, the power of its heated head and the physical properties of the icy world affect its ability to burrow down.

**"To prevent itself getting stuck an extraterrestrial melter probe will almost certainly need heaters along its sides as well"**

They've found that the gravitational pull of a world, and hence the downwards force exerted by the probe, does indeed have a significant impact. To prevent getting itself stuck, an extraterrestrial melter probe about a metre long and delivering a reasonable power to its front heater will almost certainly also need heaters along its sides as well. And for somewhere like Enceladus, with its low gravity, an additional mechanism to keep pushing the heating head forward into close contact with the ice needs to be considered.

Recent discoveries have made just this kind of melter-probe technology even more relevant. In July of this year, scientists announced the discovery of a large lake of water beneath the ice cap on the south pole of Mars. This too could be a potential habitat for life, and so is another extremely inviting target for extraterrestrial subglacial exploration. Just this sort of melter probe design, originally conceived for Europa, would therefore make an ideal mission for the Martian pole.



**LEWIS DARTNELL** is an astrobiology researcher at the University of Westminster and the author of *The Knowledge: How to Rebuild our World from Scratch* ([www.the-knowledge.org](http://www.the-knowledge.org))

**LEWIS DARTNELL** was reading... *Melting probe technology for subsurface exploration of extraterrestrial ice* by K Schüller and J Kowalski. **Read it online at** [www.sciencedirect.com/science/article/pii/S0019103518301568](http://www.sciencedirect.com/science/article/pii/S0019103518301568)



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## The Widescreen Centre Summer Events 2018

The autumn skies dominate once more and we think ahead to the darker skies and the winter observing nights to come. Events for your calendar include the International Astronomy show in Warwickshire on Friday 12th & Saturday 13th October. See [www.ukastroshow.com](http://www.ukastroshow.com) Before that, Widescreen will be at the BAA 'Back To Basics' Workshop in Bexleyheath, London, on Saturday 6th October See [www.britastro.org/meetings](http://www.britastro.org/meetings) Check in with us for other events around the country or here at our dark-sky site in Cambridgeshire [www.widescreen-centre.co.uk](http://www.widescreen-centre.co.uk)

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\*Occasionally we will be closed on Saturdays for major exhibitions such as IAS, Astrofest or Star Parties

# What's on

Our pick of the best events from around the UK



▲ Mining the Moon, life on Mars and black holes are just some of this year's topics

## International Astronomy Show 2018

Stoneleigh Park, Warwickshire, 12-13 October

IAS returns to Stoneleigh Park for two days of talks, presentations, planetarium shows and astronomy stalls.

This year's programme includes a look at how computer models help astronomers simulate the workings of the cosmos, and a guide to deep-sky astrophotography. Planetary scientist Professor Ian Crawford will explore the potential to mine Earth's Moon for vital resources, while Professor Andrew Coates, who leads the PanCam team for ESA's ExoMars 2020 rover, will discuss the latest developments in the search for life on the Red Planet.

Professor Chris Owen, who is part of the team behind the new European Solar Orbiter mission, will look at the science

of the Sun and how the orbiter could uncover the nature of solar winds.

Talks at IAS 2018 will also include a discussion on space rocks, the secrets of black holes and transient objects in the Universe. Plus, celebrated astronomer and historian Dr Allan Chapman will look back at the explosion of new technologies in the 20th century, and how they helped scientists start to answer the big questions about the cosmos.

Tickets are £8 per day in advance, and £8.50 on the day. Children under 16 years go free when accompanied by a paying adult. Lecture tickets are £6 bought in advance or £6.50 on the day. For more information visit the IAS website. [www.ukastroshow.com](http://www.ukastroshow.com)

## BEHIND THE SCENES THE SKY AT NIGHT IN OCTOBER

**BBC** Four, 14 October, 10pm (first repeat **BBC** Four, 18 October, 7.30pm)\*



An artist's impression of Britain's first ever spaceport, due to be located in Sutherland

### SPACE BRITANNIA

Maggie investigates the micro-satellites that are driving the UK's resurgent space industry, as well as plans for a new British rocket system and our first spaceport in the north of Scotland. UK astronaut Tim Peake visits the Science Museum to discover Britain's past glories in space, and where it all went wrong.

\*Check [www.bbc.co.uk/skyatnight](http://www.bbc.co.uk/skyatnight) for subsequent repeat times

## North Pennines Stargazing Festival 2018

North Pennines, 20 October – 4 November



The annual stargazing festival returns, with 30 astronomy and science events being held over two weeks. Events include Maggie Aderin-Pocock's talk on

the wonders of the night sky, a two-night star camp, a beginner's guide to telescopes, planetarium shows, an astrophotography workshop, rocket-making for kids, Solar System walks and lectures on the search for extra-terrestrial life and the mysteries of dark matter. For more information visit the festival's website.

[www.northpennines.org.uk/exploring/stargazing/north-pennines-stargazing-festival-2018](http://www.northpennines.org.uk/exploring/stargazing/north-pennines-stargazing-festival-2018)

## Galloway gathering

Drumroamin Farm, Newton Stewart, 3-8 October 2018



Join fellow dark-sky seekers for a week of observing just 30 minutes' drive from Galloway Forest Dark Sky Park. The gathering includes help and advice sessions on topics such as how to set up a telescope, what to observe and how to image the night sky. Pitches are £16 per night with access to electricity

and £14 per night without. Bookings should be made directly through Drumroamin Farm.

[www.drumroamin.co.uk](http://www.drumroamin.co.uk)

## Seafront stargazing

68 Middle Street, Brighton, 30 October, 7pm



Every month the folks at Brighton Astro meet for an astronomy-related talk followed by telescope observation sessions on the Brighton seafront. Beginners are welcome and observing sessions

are, as always, weather dependent. Attendees are required to book their place for the event, due to high demand for the club's meetings. More info is available on the (very pretty) Brighton Astro website.

[brightonastro.com](http://brightonastro.com)

## MORE LISTINGS ONLINE

Visit our website at [www.skyatnightmagazine.com/whats-on](http://www.skyatnightmagazine.com/whats-on) for the full list of this month's events from around the country.

To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the web page.





Image courtesy of Joe Canzoneri

Atik Infinity  
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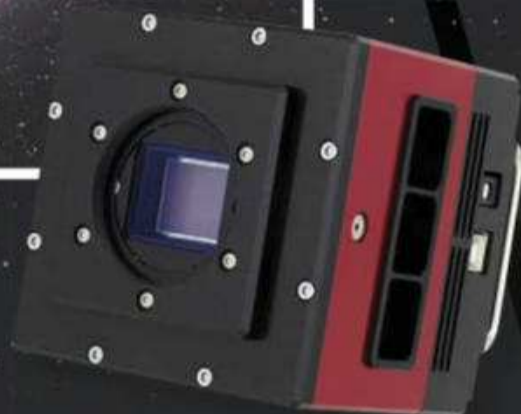
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Atik 460EX  
Mid range



Image courtesy of George Chatzifrantzis

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# A PASSION FOR SPACE



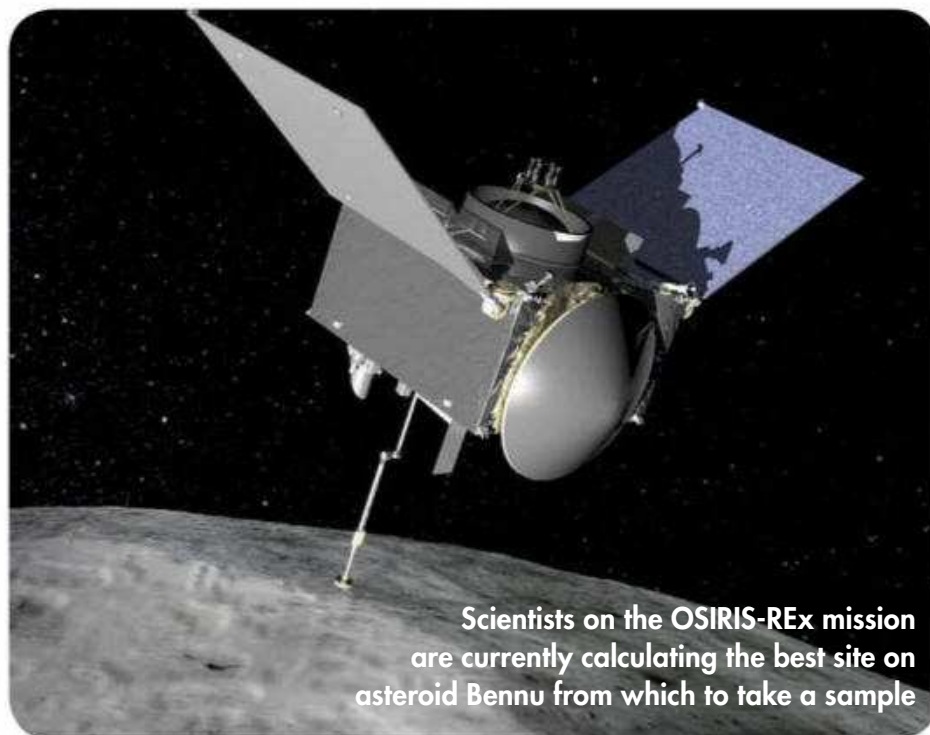
with **Kerri Donaldson Hanna**

Things are getting exciting for planetary geology as not one, but two missions make their way to asteroids

We are in the midst of a new era of space exploration – the investigation of some of the smallest bodies in the Solar System: asteroids. These primitive bodies hold vital clues about the earliest times in our Solar System including the origin of volatile- and organic-rich materials, the building blocks of life, as we know it. The exploration of asteroids allows us to better understand our beginnings here on Earth as well as the possibility of using their resources for taking humans to new places within our Solar System.

Missions to small bodies have become an international effort, with agencies from around the world actively developing and flying new spacecraft to these diverse planetary bodies. Currently two missions are underway. The Japanese Space Agency's Hayabusa2 spacecraft has arrived at asteroid Ryugu and is busy selecting a sampling site and landing spots for its rovers, while NASA's Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer (OSIRIS-REx) has begun its approach to asteroid Bennu. One of the main goals for both missions is to return samples to be studied using the best laboratories on Earth.

To pick out the best locations for collecting samples, each spacecraft will use



Scientists on the OSIRIS-REx mission are currently calculating the best site on asteroid Bennu from which to take a sample

instruments to perform reconnaissance of the asteroid's surface, identifying regions that: (1) are safe for the spacecraft to sample the surface; (2) have plenty of regolith for collecting; and (3) are scientifically compelling. This will allow us to better map asteroid compositions across the Solar System and identify planetary bodies rich in volatiles and organics.

## Fingerprinting asteroids

As a NASA-selected scientist on the OSIRIS-REx mission, the excitement for its rendezvous with Bennu in December is building. With each day, the spacecraft gets closer and closer and the view of the asteroid becomes larger and larger, allowing it to be studied in greater detail.

In preparation for the spacecraft's arrival at Bennu, our research group at the University of Oxford has been making

laboratory measurements of materials that Bennu is thought to be composed of. In particular, we've been using our bespoke vacuum chambers, which are capable of simulating the near surface conditions of asteroids, to measure the thermal infrared radiation (aka, heat) emitted from minerals, mineral mixtures, and meteorites. Different minerals and meteorites can be easily identified from one another because each has its own unique thermal infrared fingerprint (or spectrum). We've been building a library filled with thermal

infrared spectra of as many minerals and meteorites as possible. Once the spacecraft begins mapping the surface of Bennu, we will begin comparing thermal infrared spectra of Bennu's surface against spectra we measure in our laboratory at Oxford. In this way we will begin mapping Bennu's surface composition, which will be used in picking a location for collecting a sample.

Over the next year, the OSIRIS-REx team will be busy poring over the latest images and spectral maps of Bennu's surface, but it will be worth it in the end when the sample is collected and begins its journey back to Earth. We can't wait to start the analysis of the real thing! **S**

DR DONALDSON HANNA is planetary geologist from University of Oxford and a participating scientist on NASA's OSIRIS-REx mission

## JON CULSHAW'S



# EXOPLANET EXCURSIONS

Jon's epic journey through the cosmos comes to an end in a familiar place

My ship, the Perihelion, is desperately trying to stabilise after she suffered catastrophic damage near the blue hypergiant 'Saturn Star' HD 37974 (see last issue). Under regular circumstances I can enter precise exoplanetary coordinates. As it is, the Perihelion's navigational power has all but vanished. Touching down in a safe spot feels somewhat like landing Huygens using a ZX81. I'm muttering aloud in frustration and fear: "Where on Earth? We just don't know!"

Giving the destination screen a thump at first only results in a hiss of static, but then a list of generalised astronomical destinations hesitantly pulses into view. Many are obstinately unclear: GFTVAK5726892c, Sombrero Andromeda, 069573909HH24Aa. After another static burst the screen returns to a deathly blankness.

Then, with the shuddering jolt of a stalling Morris Minor, the Perihelion begins a sickening lurch so disorientating it's impossible to grasp any sense of direction or destination. It feels as if my ship is tumbling through the cosmos

like a rounded lump of cheese barrelling down a Gloucestershire hillside.

Mercifully, after four Earth minutes, there's a slowing and steadying; like a skyscraper elevator calmly arriving at the 124th floor. After my senses adjust to the welcome stillness, I gather sufficient wits to take a cautious look around outside. Whatever world this is, it's mightily strange, dark and disconcerting.

Across the sky are noxious-looking cumulus cloud formations. They're bronze and deeply sulphurous with a gentle luminescence. Is this a toxic swathe of an ammonia-like substance worthy of a gas giant?

There are more unnerving signals of life here too. Groupings of amber and white flickering lights, like compressed globular clusters, sit upon the horizon. They don't appear to be naturally occurring. The surface of the planet in this dim, gold-washed light is evocative of Huygens' images from Titan. Smooth, rounded rocks are scattered in similar fashion but in far greater numbers. They rest on a soft base of silty material like gritted, soaked clay. A body of liquid, reflecting the sulphur-shaded clouds above, swells over this terrain, but the temperature makes

it likely to be water rather than liquid methane. Most curious! Could this be an inhabited, terrestrial Earth-like planet at the far end of a Messier system?

But wait, hang on a minute... this is not just an Earth-like world, this is Earth! The bronze, glowing clouds are Earth's own, under-lit by street lamps. Those clusters of flickering lights on the horizon don't emanate from an alien super colony; that's Portsmouth. This is Selsey beach!

Earlier, as I had been muttering confusedly about final destinations: "We just don't know..." The trusty Perihelion's telepathic circuits recognised the saying and linked it to the familiar phrase often used by Sir Patrick Moore. Remarkably for the ship's addled state, its algorithms must have made the connection and autopiloted me across the lightyears, back to the planet – and indeed to the town – that Patrick called home.

It evokes a feeling of peace and a very broad smile. Local time is 10.24pm; I might make last orders at The Seal! Event Horizon Imperial Stout? Blue Moon? Hmm, I think I'll have a cup of tea.

JON CULSHAW is an impressionist, comedian and guest on *The Sky at Night*



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**MESSAGE  
OF THE  
MONTH**



## This month's top prize: four Philip's books

**PHILIP'S** The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Mark Thompson's *Stargazing with Mark Thompson* and Heather Couper and Nigel Henbest's *2019 Stargazing*.

## Swiss mechanisms

I look forward to the arrival of my *BBC Sky at Night Magazine* each month. The 'How to...' article has often given me ideas; the photo (right) shows ones I have built so far, above the Rhone valley where the viewing is usually good. The latest build has been the EQ platform for my Newtonian telescope. For the drive unit I used a stepper motor from an old printer, driving a self-built, two-stage gearbox. The stepper speed is controlled with an Arduino, powered with



building other useful gadgets in the future.  
**Ulrich Daepp, Baden, Switzerland**

*How productive you have been, Ulrich!  
It's great to see so many familiar designs  
being used in the field. – Ed*

## Tales from THE EYEPIECE

Stories and strange tales from the world of amateur astronomy by Jonathan Powell

Many years ago I decided to have my first stab at daytime astronomy. Still finding my way as a lone observer, I sought help from a more seasoned amateur who lived a fair way away, our correspondence conducted via hand-written letters. At times, I did wonder if I was exchanging post with a saint or a monk, as despite my constant boded attempts, he gave me continual encouragement and support: something we can all do when teaching others, especially when it's not face to face. I appreciated his patience, particularly because, at the time, there were no computers to help me; my only real piece of hardware – aside from my own telescope – being the angles I devised using my parents' roof as a finderscope.

Email your own tales to Jon at [TalesfromtheEyepiece@themoon.co.uk](mailto:TalesfromtheEyepiece@themoon.co.uk)



**Jonathan Powell**  
is the astronomy  
correspondent for the  
*South Wales Argus*

## No fixed time

Regarding Archie Howitt's letter in the September 2018 issue, the Sun isn't normally due south at 12:00 UTC. The 'equation of time' resulting from Earth's elliptical orbit means the Sun crosses the Greenwich meridian more than 16 minutes early in the first week of November and 14 minutes late in the middle of February.

An observer's longitude should also be taken into account. Edinburgh, where Archie is based, is more than 3° west of the Greenwich Meridian, which means that the Sun will cross the Meridian there some 12 minutes after it crosses the 0° longitude line. Using the Sun's shadow at 12:00 UTC without accounting for these two together, he could be off the true north/south line by up to 6.5°.

**Bev Ewen-Smith, Centro de Observação  
Astronómica no Algarve (COAA), Portugal**

*Thanks, Bev, for pointing out those  
important considerations. – Ed.*

## Tweets



**Jonathan White**

@JonWhite23 • Aug 22

Took this last night of the waning gibbous. Particularly enjoy the shine on the Jura Mountains at the bottom right and how the 50 mile-long Copernicus crater really stands out middle right. Just beautiful. [@skyatnightmag](https://twitter.com/skyatnightmag)



## Tweets



**Andrew Thomas**

@Andrew\_Thomas73 • Aug 5  
Yet another clear evening. Now what are the chances for next weekend? @metoffice @VirtualAstro @skyatnightmag @BBCStargazing



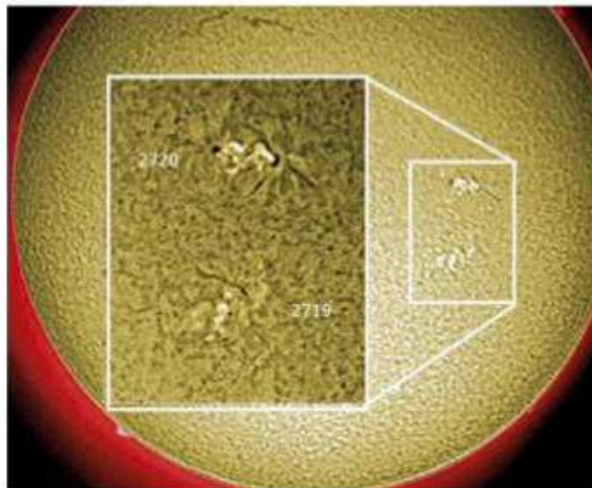
## Going underground

Given that it has taken millions of years for the surface of Mars and, indeed, other planets to become barren, is it not possible that life as we know it actually existed before Mars's loss or change of atmosphere? If they, as intelligent life forms, knew that changes were coming they would have had millennia to take evasive action. The most obvious action would be to go underground. Think of the underground Cold War bunkers built to protect us from nuclear fallout! Not totally science fiction, but could the planets

have populations deep underground who have never seen the light of day?

**John Johnston, York**

*An intriguing thought, John, but it will probably take a longer instrument than the forthcoming ExoMars rover's 2m drill to search for evidence! – Ed.*



## A rogue sunspot

Sunspots are unusual in these days of solar minimum, but this one (AR2720) is even more unusual in that it is not only large, but also strange as its magnetic polarity is reversed. The north and south ends of its magnetic field are backwards compared to the norm for sunspots in the current solar cycle, Solar Cycle 24. Could it be the first big sunspot of the next solar cycle, Solar Cycle 25? The image was taken at 09:11 BST on 25 August, 2018 from the 'windowsill observatory', Nailstone, Nuneaton, with a Lunt LS35THa and a

Bresser MikrOkular full HD camera, a focal reducer for the disc and a 2x Barlow lens for the detail.

**Roger Samworth, Nuneaton**

*That's a fascinating observation you made there, Roger. Standing by for confirmation of the next solar cycle's start from the Space Weather Prediction Center. – Ed.*

## The sweet spot

My group of University of the Third Age retirees and novice astronomers have been looking at Mars through our telescope. The planet will now forever be known as a new confectionery after one lady exclaimed, "Ooh, it looks just like an orange Smartie!"

**Barry Linton, Southend on Sea**

*I wonder if Mars's dusty 'shell' over the summer had anything to do with the observation, Barry? – Ed.*



## Meanwhile on FACEBOOK...

**WE ASKED:** What do you wish you'd known when you first started out in astronomy?

**David Pointer**

Never trust the Met Office.

**Natalia Garrett**

Don't expect to look into the telescope and see nebulae, galaxies and planets like you see in photos.

**Leslie Jones**

It's better to focus your scope using the naked eye rather than wearing your spectacles.

**David Holmes**

I started with a 40mm Tasco telescope. Wish I'd started with binoculars!

**Simon Bennett**

Keep both eyes open when using the finder.

**Keith Moseley**

Batteries fail in the cold.

**Wayne Ryles**

Be prepared for constant disappointment when the clouds refuse to part.

**David Armstrong**

Astronomy is a good excuse to visit fabulous locations that have clear skies and kangaroos.

**Dave Theafish**

The best time to see anything and everything is always the coldest or latest time of night.

**Tara Lee Renda**

It really DOES take 20 minutes for your eyes to adjust to the dark. You see so much more!

## SOCIETY in focus



The Sunderland Astronomical Society (SAS) 'Starbeque' is an annual event to celebrate the beginning of the society's observing season, held at our dark-sky site at Derwent Reservoir

every August. It has grown from humble beginnings and this year 27 people came along and 12 scopes were unpacked. This, despite the knowledge that there was to be 100 per cent cloud cover all night; the big beasts like the 16-inch Dobsonian sadly did not make it out of the van.

The event is much more than an observing session at a dark-sky site, though: it is a chance for members and their families to celebrate the coming of darker nights, meet friends whom they may not have seen over the summer, and, of course, show off

all the astro-related gear and toys they've acquired since we last met.

This year, we were able to sit out on a balmy evening, instead of huddling under tarpaulins in the rain to prevent the water drenching the BBQs – yes, that's happened in the past! It was lovely to see a good number of first-timers and new families with 'starkids', who were impressed with the view through the scopes of upside-down sheep on a hill opposite despite the cloud being too thick to see anything celestial.

SAS was formed in July 1993 by an enthusiastic group of local astronomers. We are a very active society whose aim is to promote, inspire, inform, empower and advance the awareness and education of the public in the science of astronomy. We meet every Thursday and Sunday at our Observatory at Washington Wetlands Trust. Our motto is 'Who Stares Wins'.

**Michael Tweedy, FRAS**  
Chair, Sunderland Astronomical Society  
[sunderlandastro.com](http://sunderlandastro.com)

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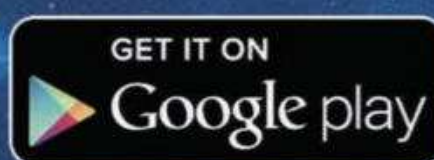
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# Hotshots

This month's pick of your very best astrophotos

**YOUR  
BONUS  
CONTENT**

A gallery  
containing these  
and more of your  
stunning images

**PHOTO  
OF THE  
MONTH**



## ▲ The North America Nebula

REZA HAKIMI, MOOMEJ, IRAN, 10-11 JULY 2018



**Reza says:** "This nebula is one of the most iconic objects for imaging, so I thought it would be worth a try. I spent two nights in a Bortel Class 3 site

to collect the data needed, and the first night was disastrous! My power generator broke down, I had mount problems and the appearance of dew, but I am glad at how it turned out in the end."

**Equipment:** ZWO ASI1600MM-C camera, Canon EF 200mm f/2.8 lens **Exposure:** 40x5' Ha, 33x5' OIII, 29x5' SII

**BBC Sky at Night Magazine says:** "Images of nebulae are a great opportunity to play with the contrast between colourful, glowing clouds and thick, dark dust. Reza has done an immense job with this one. The multitude of crisp stars and the intricacy of the dusty

tendrils makes this an image that really pulls the viewer in."

**About Reza:** "I'm a 28-year-old engineer, drummer and astrophotographer from Tehran. I started astrophotography about three years ago and it has become my full-time passion. I have enjoyed stargazing since I was a kid. A wise man asked me, 'Why don't you take a picture of it?' so here I am!"



## ◀ ISS, Mars and Milky Way

CHRIS POMEROY, CYPRUS, 3 AUGUST 2018



**Chris says:** "I wasn't planning on capturing the ISS and only noticed it after I took the photo. I was lucky but have got the bug now and plan to capture the ISS across the entire frame."

**Equipment:** Sony  $\alpha 7$  III camera, Samyang 14mm f/2.8 lens, Star Adventurer Mini mount  
**Exposure:** ISO 1600, 147" **Software:** Adobe Lightroom, Photoshop



## ▲ The Eagle Nebula

MARK CROWTHER, CHELTENHAM, 3 AUG 2018



**Mark says:** "I had about four hours before the Eagle got too low to image. I'm going to further process to emphasise the blues and oranges in the lighter areas."

**Equipment:** ZWO ASI1600MM-C camera, TS-Optics 8-inch f/8 Ritchey-Chrétien astrograph, iOptron iEQ45 Pro Go-To equatorial mount **Exposure:** 1.5h **Software:** Astro Photography Tool, PHD2 guiding, GIMP

## AR2713 ▶

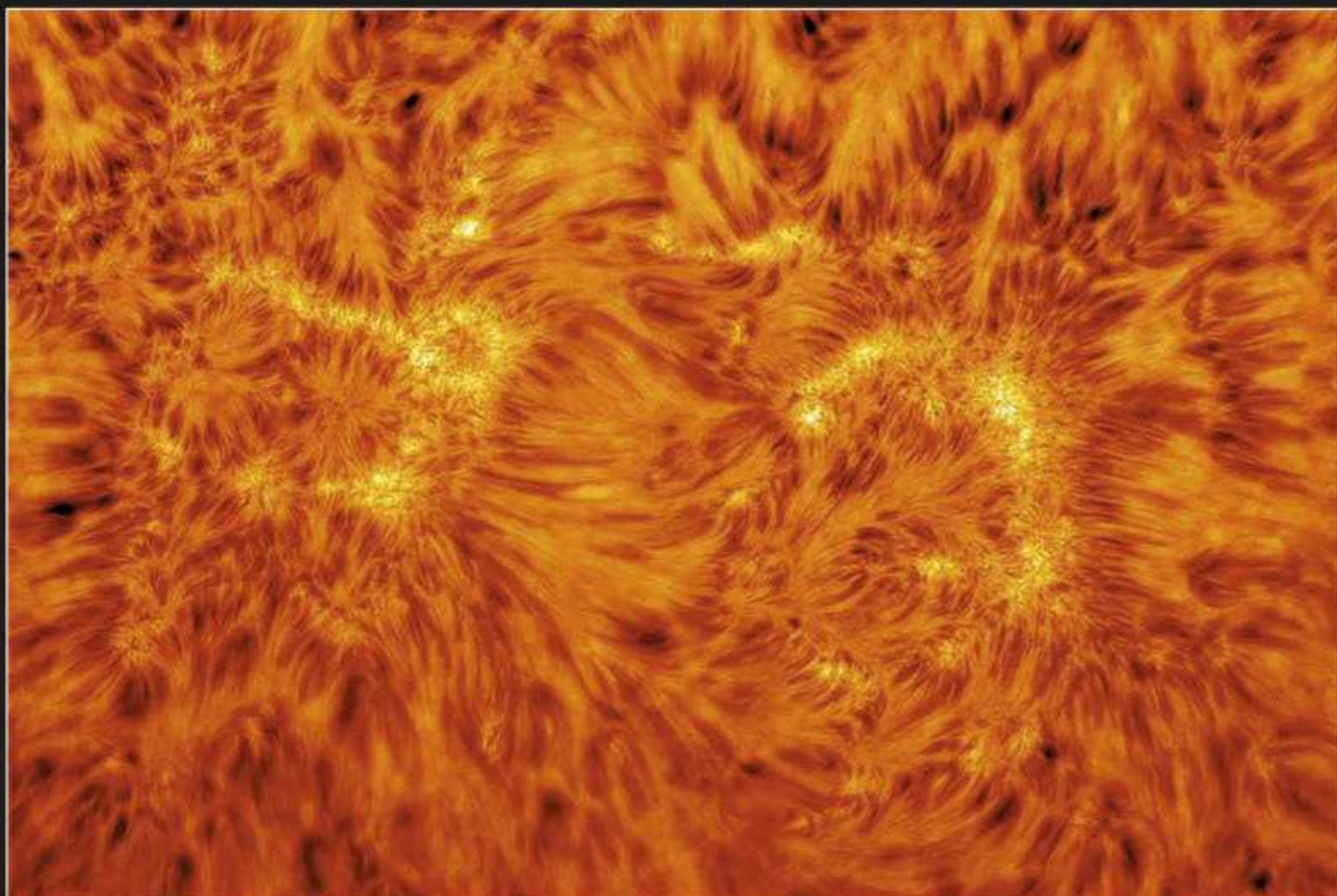
EWAN HOBBS, HASTINGS,  
15 JULY 2018



**Ewan says:** "The active region showed promise and some fine, delicate detail, which is what I like imaging most."

Seeing was the best from this location I've had in a long time and having a fairly hi-res setup means I am lucky enough to be able to capture smaller detail often missed."

**Equipment:** Point Grey IMX174 mono camera, Tecnosky 152mm f/5.9 refractor, Sky-Watcher AZ EQ6 Go-To mount, Baader D-ERF 135mm energy rejection filter, Daystar Quark Ha chromosphere filter **Exposure:** 30 seconds, 125fps **Software:** Genika Astro, AutoStakkert!, ImPPG





## ◀ The Trifid Nebula

LUIS FERNANDO PARMEGIANI, PADRE BERNARDO, BRAZIL, 12 JULY 2018



**Luis says:**  
"With an open cluster

and three types of nebulae, Trifid for me is particularly beautiful. This image was captured at an astrophotography meeting in Brazil, and I took advantage of the dark sky to bring out the details."

**Equipment:** QHY9M mono CCD camera, GSO 8-inch Ritchey-Chrétien **Exposure:** 56x120" each LRGB **Software:** PixInsight

## Triangulum Galaxy ▶

JONATHAN TITTON, PADRE BERNARDO, BRAZIL, 14 JULY 2018



**Jonathan says:**  
"Excellent result for a stock

camera; the galaxy was very clear and full of small details"

**Equipment:** Canon EOS 6D DSLR camera, Explore Scientific ED102 triplet refractor **Exposure:** ISO 1600, 24x240" lights, 80x240" blacks, 80 frames bias, 80 frames flats **Software:** PHD2, Astro Photography Tool, PixInsight, Photoshop



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## ENTER TO WIN A PRIZE!

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We've teamed up with Altair Astro UK to offer the winner of next month's Hotshots an Altair Astro Premium 1.25-inch CLS-CCD Filter with UV/IR Block & AR Coating, designed to reduce the effects of light pollution and skyglow for DSLR, CCD or CMOS cameras – [www.altairastro.com](http://www.altairastro.com) • 01263 731505

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# 15 THINGS

## stargazers should know

Books and guides can be a great introduction to astronomy, but nothing beats experience. The more you stargaze, the more you'll learn. Here are some things you'll become aware of in your first year of observing, writes **Jamie Carter**



#### ABOUT THE WRITER

Jamie Carter is a seasoned astronomer and author of *A Stargazing Program for Beginners: A Pocket Field Guide*

Practical, hands-on observing is often the best way to truly get to grips with the subtleties of stargazing

# There's an 'observing window' each month

Bright moonlight is a big light polluter, so it pays to keep track of the Moon's movements and phases. From about four days after new Moon, our lunar neighbour grows from a slim crescent to a bright orb that blots out stars right up until about six days after full Moon, after which it doesn't rise until the early hours. As a result, there's a window

of about 12 days surrounding new Moon when you're assured of a dark Moonless sky that is ideal for stargazing.

**HOW TO FIND IT:** Get a poster of Moon phases or find the info online and be sure to plan any stargazing activities around new Moon. ▶



▲ You can find the same information on the internet but nothing beats the at-a-glance simplicity of a Moon phase poster

The Pleiades is the most easily visible open cluster in the night sky with the naked eye



M45, the Pleiades

# Find that unmissable 'smudge' in the winter night sky

Does a bright blob always catch your eye when you're out stargazing in autumn and winter? It's almost certainly the Pleiades (M45), a cluster of stars 440 million lightyears distant that's also called the Seven Sisters. It's a young cluster of stars just 100 million years old. Even with the naked eye you should be able to make out about five or six of its stars forming the shape of a mini Plough.

**HOW TO SEE IT:** Low in the east at dusk in November, the Pleiades is a gem of the winter night sky. Part of the constellation of Taurus, it's visible every night until May.

Top tip for observing the full Moon – catch it early



## Night vision makes stargazing much easier

As your eyes grow accustomed to darkness, your pupils dilate and allow in more light. It's why patience is so important when stargazing.

**HOW TO GET IT:** Keep away from all bright lights for at least 20 minutes (yes, that absolutely *does* include your smartphone!) and, if you do need to use illumination in the field (to read or make notes), use a dim, red light.

## Observing the full Moon is best done at moonrise

Most beginners presume that the best time to observe the Moon is when it's high in the night sky, but at that point it's way too bright. Instead, find out the exact time of moonrise on the night of the full Moon and watch our satellite appear on the horizon during dusk in a gorgeous pale orange colour.

**HOW TO SEE IT:** Get somewhere reasonably high with a clear view of the eastern horizon at dusk on the night of the full Moon.



Use a red light when observing to maintain your dark-adapted vision

# Light pollution can be helpful

A dark sky full of stars is an incredible sight, but light pollution isn't always a bad thing. When you're trying to learn the shapes made by the main, bright stars of constellations, the fact that the background of thousands of stars is 'missing' because of urban lighting can actually be useful. So for now learn to live with light pollution... you'll grow to hate it soon enough.

**HOW TO AVOID IT:** If you're stargazing from an urban area, stand in the shadow of a building where there are no streetlights or other lights directly in your field of view.



Try thinking of urban glow as a handy beginner's filter



Some meteor showers are more reliably spectacular than others

## Pick your meteor-spotting sessions carefully

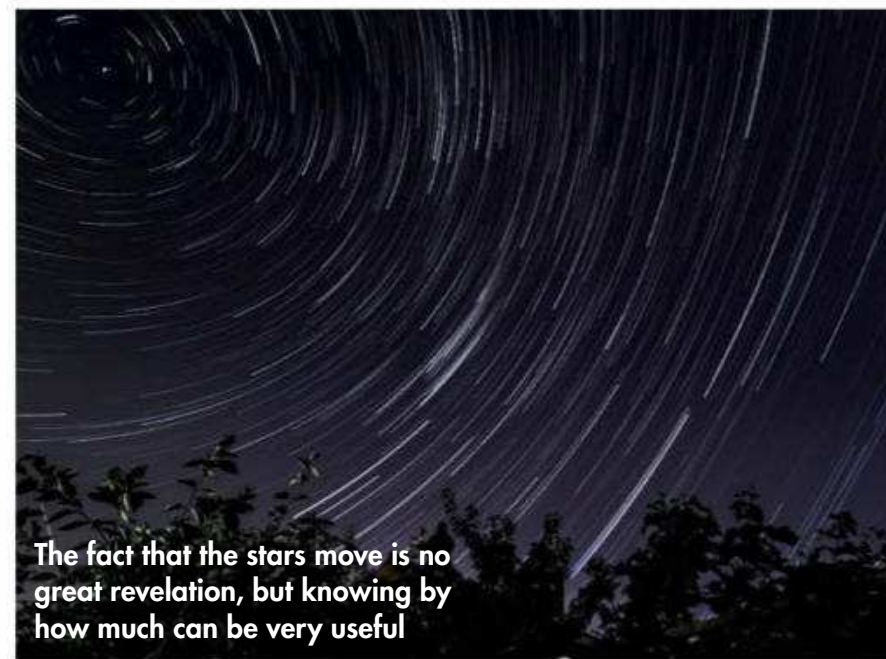
The thought of shooting stars 'raining down' is enough to excite any stargazer, but in practice many of the minor meteor showers can be a let-down. Firstly, it's quite often cloudy on 'peak' night. Secondly, the number of meteors you can see in an hour of peak activity is changeable. Thirdly, strong moonlight and light pollution can completely wipe out most of them.

**HOW TO SEE THEM:** Minor meteor showers such as the Lyrids, Orionids and Leonids produce at most 10-20 shooting stars per hour, and of those far fewer are likely to be easily visible. Their peak nights are best treated as great nights to go general stargazing, with the added bonus of seeing a few shooting stars. Only the year's major meteor showers – the Perseids in August and the Geminids in December – are worth a dedicated trip to a dark sky site.

## The changing sky

As Earth orbits the Sun, the positions of stars change slightly, rising in the east four minutes earlier each day. Consequently, the entire night sky appears to shift forwards by four minutes each night. You most likely won't notice this if you spend a few consecutive nights stargazing at the same time of night, but over the course of a month it's a two-hour difference. So stars rising at 10pm in October can be seen at 8pm by November.

**HOW TO SEE IT:** Look at the sky at a completely different time of night than you're used to. In fact, if you stargaze at 2am in October you're actually looking at the same night sky that will be visible at 8pm in February. So it doesn't actually take a year to observe all the seasonal stars and constellations, after all.



The fact that the stars move is no great revelation, but knowing by how much can be very useful



The peak of the 'Milky Way season' is around the June solstice

## The Milky Way is only overhead in summer

That bright core of our Galaxy that you always see in photographs is only visible overhead during summer, when Earth is facing towards the centre of the Milky Way about 75,000 lightyears away. In winter, we're looking outward into deep space.

**HOW TO SEE IT:** Look southeast after dusk in June, July and August from a dark sky site. ►

# Some stars are visible all year long

URSA MAJOR

URSA MINOR

Polaris

CASSIOPEIA

Earth's northerly axis points roughly to Polaris, the North Star, which appears stationary in the night sky as all other stars in the northern sky appear to revolve around it. The two close constellations of the Plough and Cassiopeia are thus always visible to stargazers in the northern hemisphere. In the rest of the northern hemisphere sky, stars rise in the east and set in the west. Further south, there's a whole hemisphere of stars and constellations that we, at our northerly altitude, never get to see.

**HOW TO SEE IT:** Look north at any time of year to find Polaris between the Plough and Cassiopeia (though in autumn and spring they can get lost on the horizon). If you stargaze at the same time of night throughout the year, you'll see that stars and constellations are each visible for six months, during which time they shift slowly from east to west. For the rest of the year, they're only 'up' during daylight.

In the northern hemisphere, the entire sky revolves around the Pole Star, Polaris

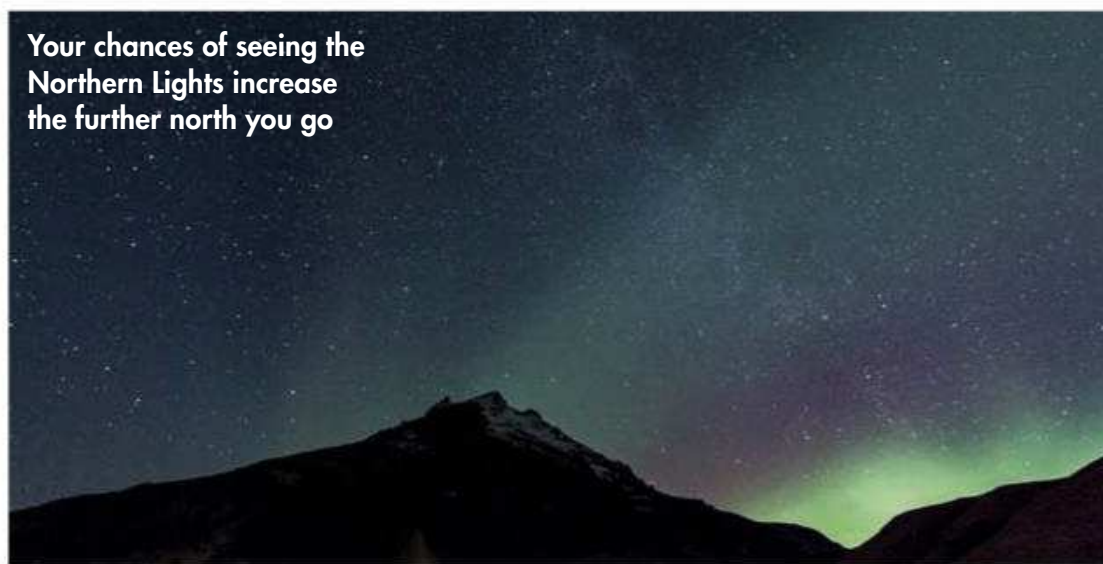
## Satellites are a regular sight

You don't have to stargaze for long before you see a satellite whizz across the night sky. During an hour's stargazing you can see dozens, all of which are over 6m in length and in a low-Earth orbit around 160-640km up. You're looking at reflected sunlight, so it's a constant light unlike the flashes from aircraft.

**HOW TO SEE THEM:** You'll see more satellites just after dusk and just before dawn, though in the UK summer the Sun doesn't sink as far below the horizon, so satellites can be seen all night.

Shooting star or satellite?  
Is it wrong to wish on  
space hardware?

Your chances of seeing the  
Northern Lights increase  
the further north you go



## Travel north for a better chance of an aurora sighting

The result of electrically charged particles ejected from the Sun interacting with Earth's magnetic field and atmosphere, the Northern Lights, or Aurora Borealis, move in an oval shape around the Arctic Circle on the night-side of Earth. These aurorae wax and wane from north to south, so they can occasionally be seen from Scotland, northern England and north Wales.

**HOW TO SEE IT:** If you want to maximise your chances, take a trip to a place within the latitudes of 64° and 70° north between October and March: places such as Iceland, northern Norway, Lapland in Finland or Sweden. However, if there are huge sunspots, stargazers can sometimes see a green glow on the northern horizon from the UK. The best places are Scotland's northern coast and Orkney (both at 59° north), and the Shetland Islands (60.5° north).

## Your peripheral vision is powerful

The human eye's peripheral vision is very sensitive to brightness, so look slightly to the right of a star cluster, nebula or galaxy to see its glow. Conversely, when observing a star or planet, look directly at it to see colour.

**HOW TO SEE IT:** Look just above the Pleiades for a good lesson in this 'averted vision' technique, which works just as well with the Orion Nebula (M42), the Andromeda Galaxy (M31) and any star cluster.

Although it seems counter-intuitive, not looking directly at a galaxy can make it appear brighter



## Flaring could be satellites

If you see a satellite suddenly go extremely bright for a few seconds before fading fast, that's an 'Iridium flare', a glint off one of a network of satellites from the Iridium Satellite Communications company. If it was much quicker, you probably saw a meteor.

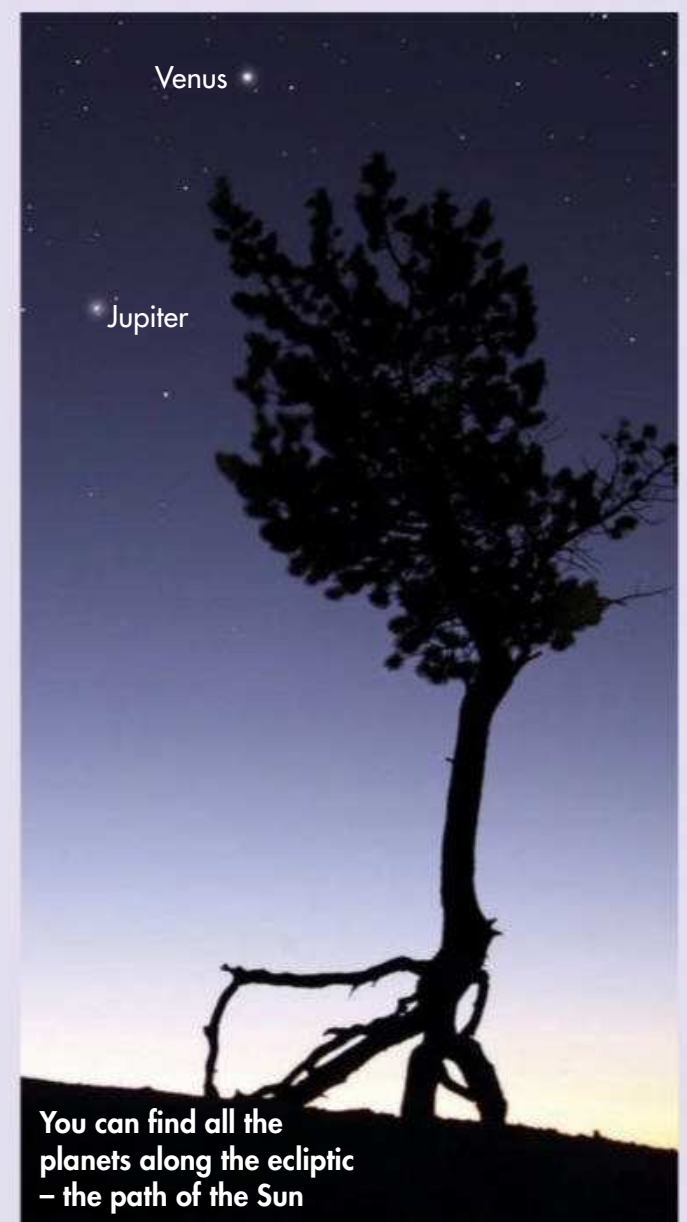
**HOW TO SEE THEM:** Since Iridium is now de-orbiting its old flaring satellites and replacing them with smaller ones, flares are becoming rarer. They are due to be nonexistent by the end of 2018 so if you want to see one, be quick! Visit [heavens-above.com/IridiumFlares.aspx](http://heavens-above.com/IridiumFlares.aspx) to get exact timings for where you live.



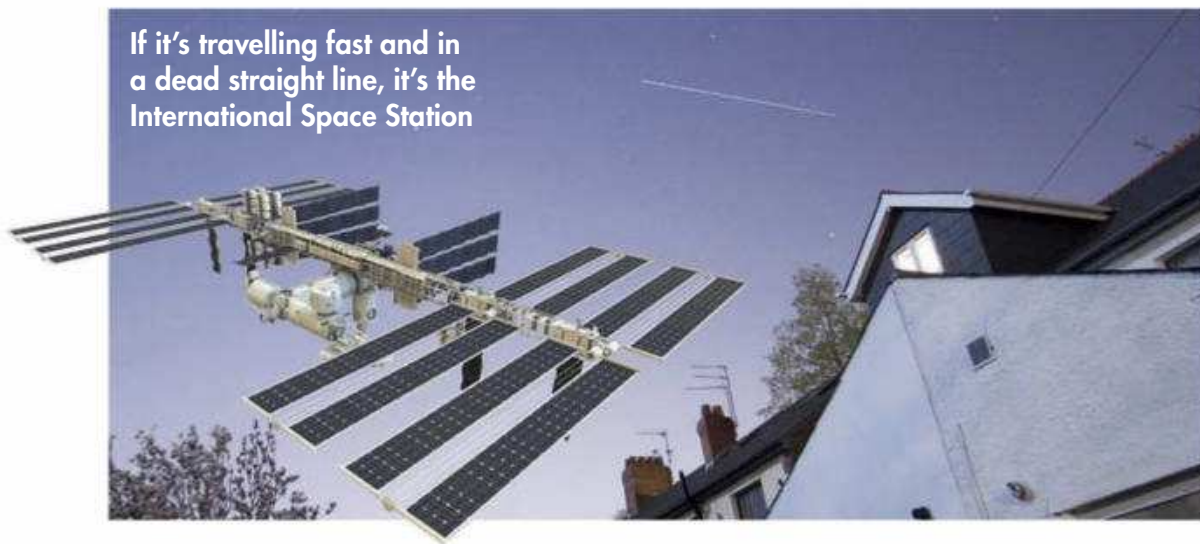
## Planets are very easy to find

The Sun and the planets appear to move across the sky on roughly the same path, which reveals that all the planets in the Solar System orbit the Sun in a virtually flat disc. This is called the ecliptic, and it's here that you'll find the planets close by. The Moon also roughly follows the ecliptic.

**HOW TO SEE IT:** The ecliptic stretches from the point on the eastern horizon where the sun rises to where it sets in the west; look to the south after dark and trace the position of the planets. Since Mercury and Venus are inner planets, they are only visible in the west soon after dusk, or before dawn. **S**



If it's travelling fast and in a dead straight line, it's the International Space Station



## Spot the space station moving from west to east

If you see a bright light rise roughly in the west, get extremely bright and then disappear in the eastern sky, you probably just saw the International Space Station (ISS) or, rather, its huge solar panels reflecting sunlight. The ISS orbits Earth 16 times each day at 27,600km per hour, which is around 8km per second.

**HOW TO SEE IT:** You can only see the ISS when it's crossing overhead just after dusk and just before dawn. If you do see it soon after dark, wait 92 minutes and you'll probably see it again. Visit NASA's [spotthestation.nasa.gov](http://spotthestation.nasa.gov) website to get exact timings for where you live.



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# Shooting the Milky Way's WIDE-FIELD WONDERS

Astrophotographer **Will Gater** explores the attraction of imaging our Galaxy's treasures with a tracking mount, DSLR and long lens

WILL GATER



#### ABOUT THE WRITER

Will Gater is an astronomy writer and presenter. Follow him on Twitter at @willgater or visit willgater.com

**A**strophotography can offer an interesting opportunity to look at the bigger picture. This is especially true of deep-sky imaging where wide-field photographs can show star clusters, nebulae and galaxies in context amid their broader surroundings.

In this article we're going to explore capturing wide-field deep-sky images using a DSLR camera, motorised tracking mount and a – relatively – long camera lens. While that may seem like a fairly simple kit list compared to modern 'close-up' deep-sky imaging rigs, such a setup can nonetheless produce spectacular results.

What's more, with the last of the summer Milky Way low in the southwest and the magnificent disc of the Galaxy running high overhead this month, there's a tremendous array of potential targets for this kind of astrophotography in October's night skies. So whether your subject is the star fields of Scutum and Aquila or the regions of nebulosity in Cygnus, there's never been a better time to start photographing the Milky Way's wide-field wonders.

One of the most attractive aspects of imaging deep-sky targets with a DSLR and motorised mount is that it is much less demanding on the mount's tracking capabilities than a traditional deep-sky



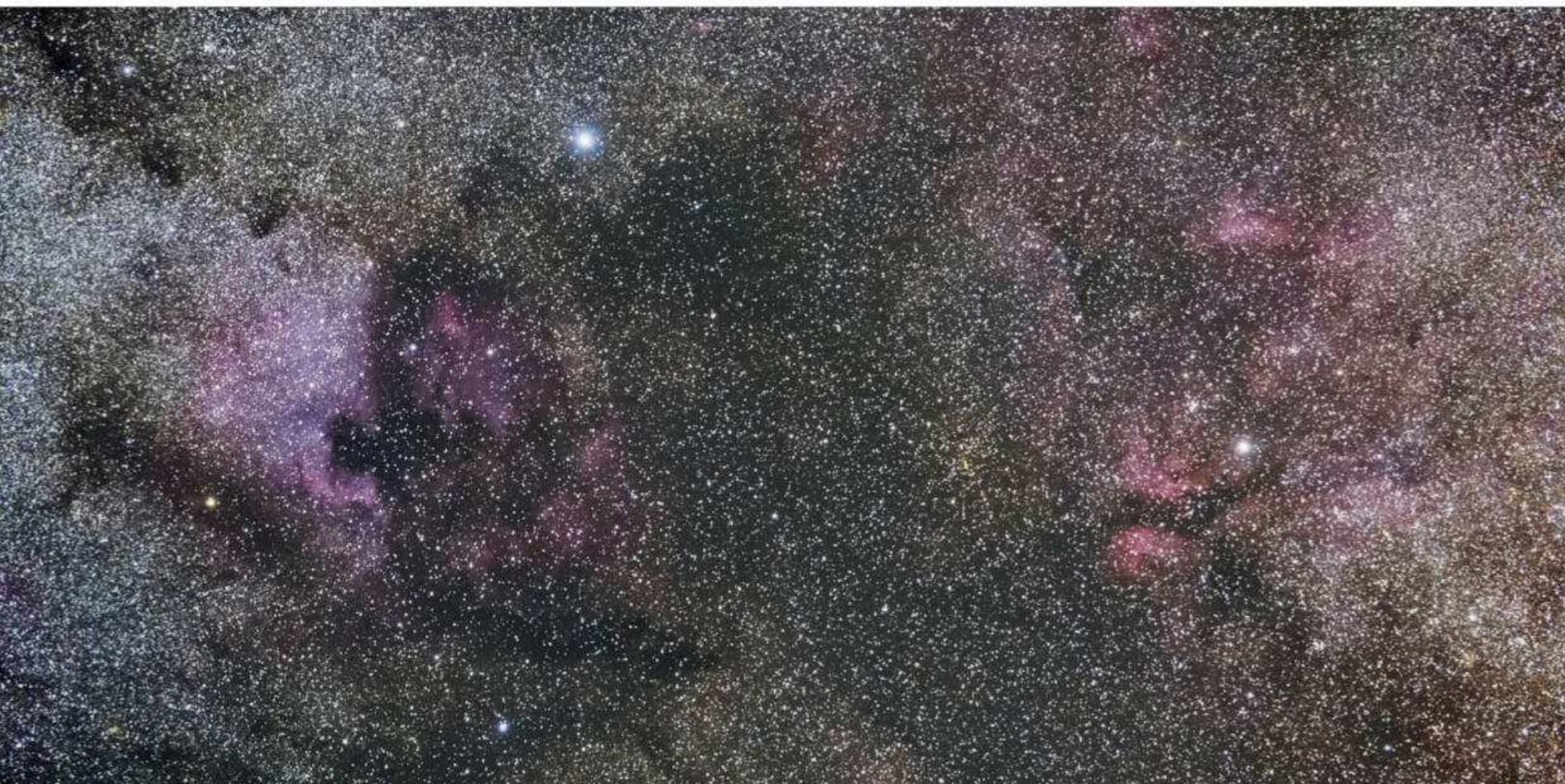
setup. With the latter, the view of a celestial object is highly magnified on the camera chip, meaning that you'd usually have to use another scope, camera and computer in conjunction with the main imaging telescope to 'autoguide' out any small imperfections in the mount's tracking. With a wide field of view you shouldn't need any of this kit. As long as your mount is reasonably well polar aligned and you can get exposures of a few minutes in length from the setup without the stars blurring, you should be fine. The trade-off, of course, is that the view of a deep-sky object or celestial scene is much less magnified and set within a larger field of view – but as we've already discussed, that's not always a bad thing.

The fact that only a basic, but sturdy, driven mount is needed makes this perfect for deep-sky imagers who need, or want to travel further afield for their photography. Both small equatorial mounts with a single, battery-powered motor or portable tracking mounts lend themselves well to astrophotography of this kind.

As well as the mount and the camera itself, the other key component is the lens you use. In our opinion, suitable lens focal lengths for this type of

▲ All the astrophotos in this article were taken using a Canon 6D DSLR and 135mm lens on either a portable tracking mount or a full Go-To mount. This is Barnard's E with the bright star Altair to the left and the dust lanes of the Milky Way on the right

▼ The North America Nebula with the Sadr region to the right



# TOOLS FOR THE JOB

Wide-field, deep-sky imaging with a DSLR and a long lens requires a motorised mount. Here are two example setups

## STANDARD EQUATORIAL TRACKING MOUNT

A motorised equatorial mount like this one – fitted with a Go-To handset – is normally used with a telescope or a full deep-sky imaging rig. Here we've simply repurposed it, using an inexpensive adaptor, to hold a DSLR and lens.

### Basic telephoto lens

This basic lens is more than capable of producing decent wide-field images. The key with cheaper lenses is to 'stop down' their aperture to reduce the effects of chromatic aberration on stars.

### Dovetail bar adaptor

There are several different adaptors – incorporating a 'dovetail bar' – available that will connect a DSLR camera to a mount. This more advanced version can be bought for under £30.

### Go To mount

This substantial mount will have no problem carrying a DSLR camera and lens while keeping wind vibrations at a minimum – perfect if you're imaging with a longer focal length lens.

## PORTABLE TRACKING MOUNT

Modern, portable mounts, like this one, are compact, lightweight and can track accurately, making them ideal for 'grab-and-go' deep-sky imaging. But you needn't have something this fancy for wide-field DSLR work with a camera lens – a simple, well-balanced motorised equatorial mount should work fine with a shorter focal length lens.

### Prime lens

This fast, prime lens – with a 135mm focal length – is well suited to wide-field, deep-sky astrophotography. It has a large lens hood which helps keep dew away during long imaging sessions.

### Ball head adaptor

A ball head adaptor can make swivelling your DSLR around to line up and frame a shot much easier. Be sure to check that the model you use can comfortably hold the weight of your camera body and lens.

### Photo tripod

Portable tracking mounts typically connect to standard tripods. This means the setup can be quickly and easily assembled or packed away for imaging trips further afield.

wide-field imaging work sit roughly between 90-200mm. Having the right equipment will only get you so far, though. The real secret to a successful deep-sky, wide-field shot is framing and composition.

## Software solutions

Planetarium apps and software like SkySafari and Stellarium can help with this. Stellarium's 'Oculars' plug-in, which overlays a given astrophotography setup's field of view on the sky, is particularly useful for scoping out potential compositions; it really comes into its own, however, when combined with Stellarium's ability to project various astronomical survey images onto the simulated sky using the recently added 'Surveys' feature.

For example, if you go into the 'Surveys' tab via the viewing options window (F4) you can select from the menu the option to show 'DSS colored', which displays deep-sky imagery from the Digitized Sky

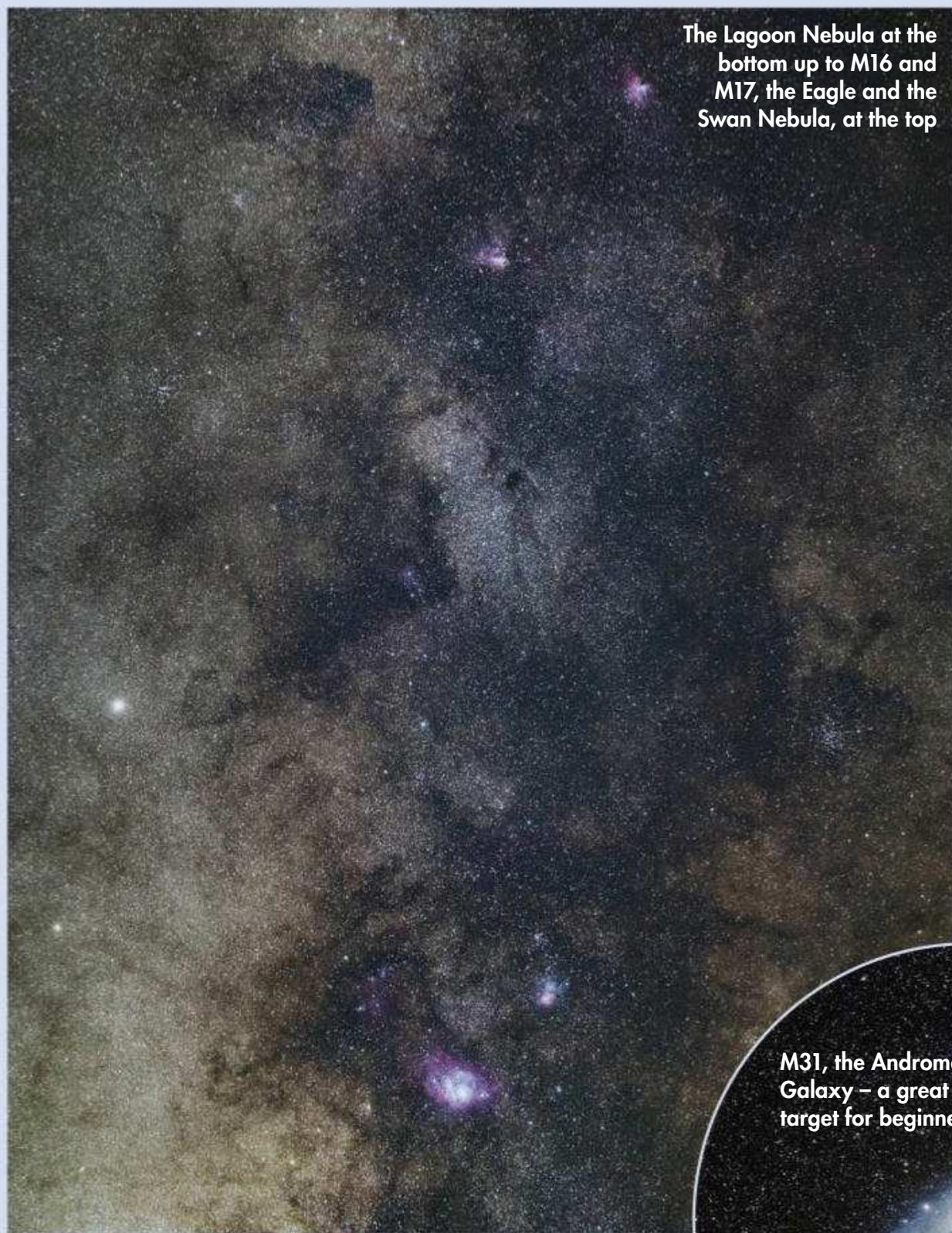
Survey (DSS). This is really helpful for planning wide-field, deep-sky images where you've got a lot of dense Milky Way star fields or bright emission nebulae. That would certainly be the case this month if you wanted to image, say, the mixture of nebulae, dust clouds and star fields that sit on the borders between Scutum, Ophiuchus and Sagittarius.

With the DSS image data displayed you can see these regions in far more detail than is generally shown in the main Stellarium simulation. And with the field-of-view box enabled from the 'Oculars' plug-in you can then play around with different lens focal lengths and camera orientations to create the most aesthetically pleasing framing. Once you've settled on a composition that you like, note the positions of the brighter stars in the view, as this will help when you come to initially frame up your shot in the field.

When you have your equipment set up under the stars and your subject framed and focused, it's worth ▶

# WONDERS TO WATCH

10 of the best wide-field, deep-sky targets for your DSLR and long lens this month and beyond



The Lagoon Nebula at the bottom up to M16 and M17, the Eagle and the Swan Nebula, at the top

## The Elephant's Trunk Nebula and surroundings

The region of the constellation Cepheus containing the Elephant's Trunk Nebula and the famous Garnet Star (Mu ( $\mu$ ) Cephei) makes for an attractive wide-field panorama. This month it sits high overhead at midnight.

## The rest of the year

### Cassiopeia

While an entire constellation might not seem like an obvious target for deep-sky work, Cassiopeia – replete with numerous clusters, star fields and nebulae – fits beautifully inside the field of view of a 90mm lens on a full-format DSLR camera.

### The Andromeda Galaxy (M31)

Its large apparent size and brightness make M31 a great object to set your photographic sights on if you're just starting wide-field, deep-sky DSLR imaging. There's something magical about capturing Andromeda set among the scattered stars of our own Galaxy.

### Dark dust clouds in Taurus

The region roughly halfway between the Pleiades star cluster and the bright star Beta ( $\beta$ ) Tauri contains a large expanse of dark, dusty nebulosity that can be a challenging, but rewarding, target to go after under dark skies.

### Nebulae in Orion

A treasure trove of nebulae, the constellation of Orion contains plenty to keep a wide-field, deep-sky imager occupied. If you're looking for a challenge, try to capture some of the very dark, dusty nebulosity that surrounds more familiar targets like M42.

### Spring galaxies

While most galaxies tend to look better at high magnification, wide long-exposure images still have a certain majesty to them. For example, they can show the myriad galaxies on the border of Virgo and Coma Berenices as numerous tiny smudges of light strewn across space.

## This month

### The Eagle and Swan Nebulae (M16 & M17)

These two bright emission nebulae, catalogued as Messier 16 and 17, sit nestled within sparkling fields of stars. Their bright pinkish colour contrasts beautifully with the whites and ochres of the rich star fields and the surrounding dark dust lanes.

### Barnard's E and surroundings

This striking E-shaped dark nebula appears in silhouette in front of the dense star fields of the Milky Way in Aquila. Although dark, it's an easy target to find with a few quick test exposures as it's very close to the mag. +2.7 star Tarazed (Gamma ( $\gamma$ ) Aquilae).

### The North America Nebula and Sadr region

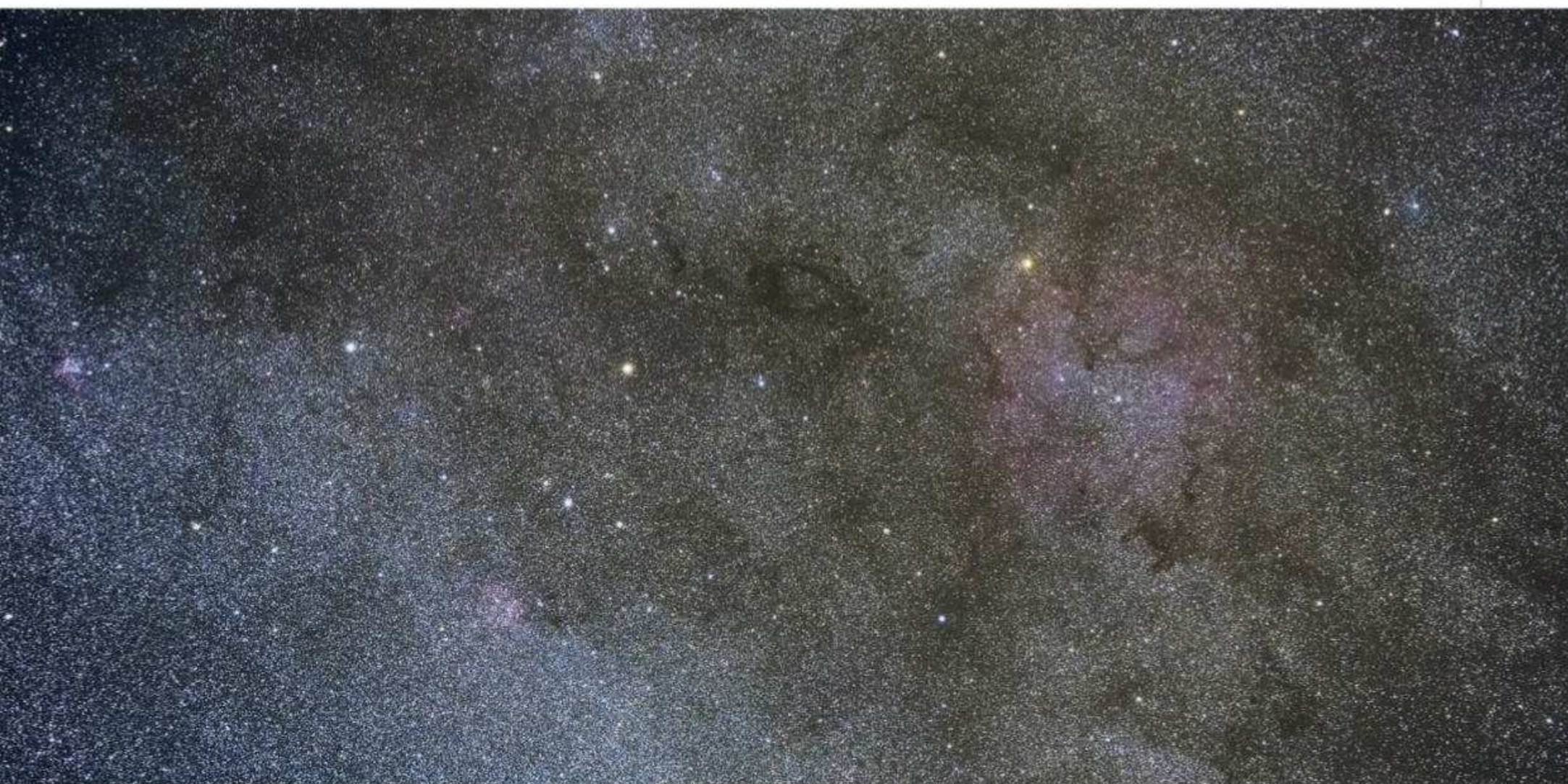
While off-the-shelf DSLR cameras can sometimes struggle to capture the reds of emission nebulae, these two prominent regions of glowing nebulosity in the constellation of Cygnus show up fairly easily in long-exposure, wide-field images.

### The Scutum star cloud

This patch of bright Milky Way star fields in Scutum is easily visible to the naked-eye from a relatively dark suburban site. Its large apparent diameter makes it a superb target for wide-field imaging with a DSLR camera.

M31, the Andromeda Galaxy – a great target for beginners





▲ The Elephant Trunk Nebula can be seen inside the much larger ionised gas region IC 1396 (the pinky fuzz to the right of the image), which also includes the bright orange Herschel's Garnet's Star (on its top-left border in this image)

▼ The DSLR camera's screen displays a flat-field image taken using the method described in the article. The histogram shows that it's been exposed properly too

► doing some initial exposure tests for light pollution, as this is one of the main things that impacts imaging of this kind. You want to find an exposure length and ISO-setting combination that gives you detail in any faint star fields or nebulae in shot, but where the background skyglow doesn't 'fog' out the whole frame. If in doubt, it's better to err on the side of a darker exposure setting. (For more on dealing with skyglow, see Image Processing on page 83.)

If you've decided to image a patch of the Milky Way dominated by dark dust clouds and dark nebulae set against dense star fields – like the region to the west of the bright star Altair, for example – try to keep the ISO setting on your DSLR low (in the region of 200-400) if you can; that's because camera noise can be very noticeable in darker regions of an astro image, so shooting with a lower ISO will result in those areas appearing smoother and less noisy. Similarly, experiment with aperture setting


before imaging. 'Stopping down' or reducing the aperture by a few stops can often reduce vignetting – a darkening effect around the corners and edges of a photograph – and improve the sharpness of stars.

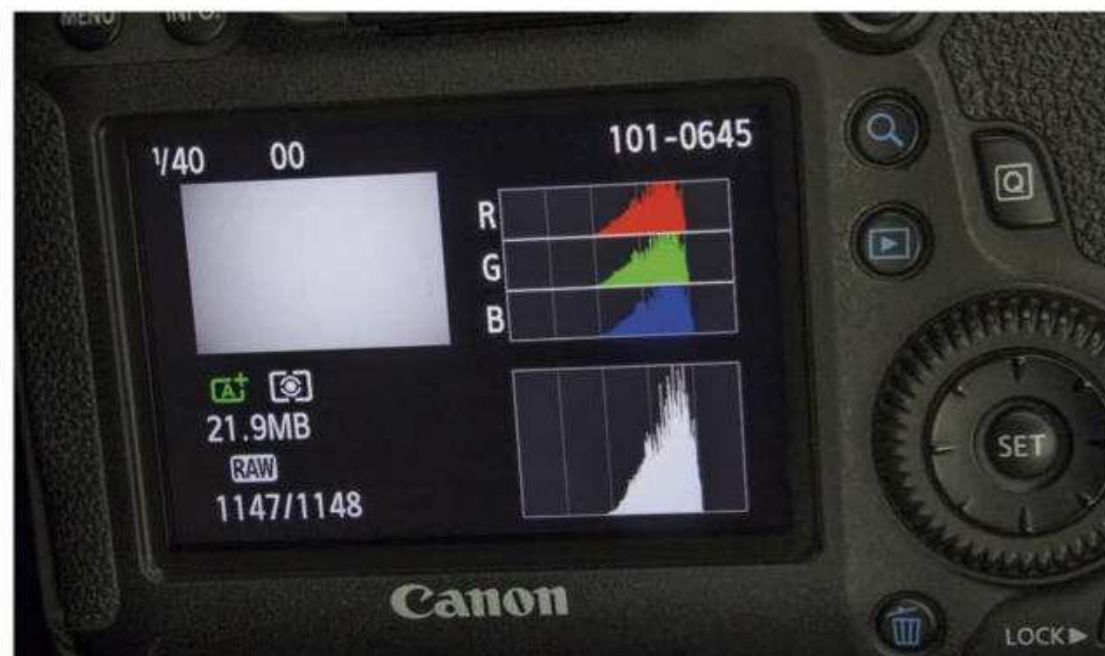
## Flat and dark frames

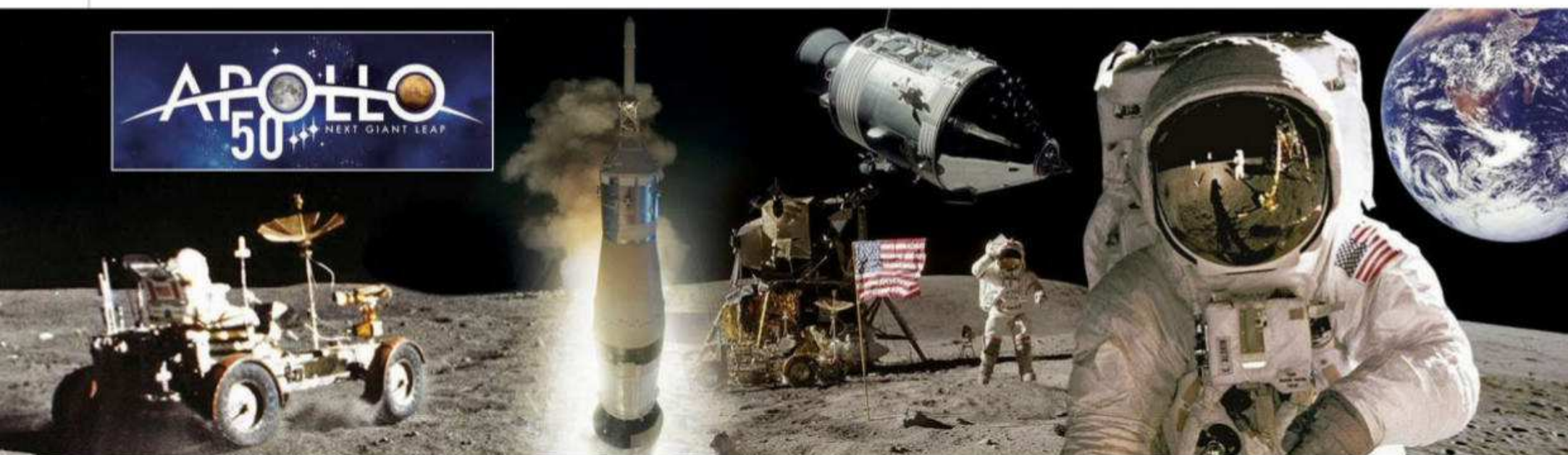
Once you're happy with your settings, capture at least 20 to 30 minutes' worth of exposures, discarding any that contain signs of thin cloud or airglow. Also take a set of 'dark frames'; images captured under the same conditions and settings as your images of a celestial target, except with the lens cap on. They will help reduce the effects of camera noise during processing.

Before packing up, it's also important to capture a set of 'flat frames', another form of calibration image used to remove the effects of vignetting and other optical artefacts. Take them by setting your DSLR to auto-exposure then stretching some plain, white fabric over the end of the lens hood; illuminate the fabric with a torch or headlamp and fire the camera shutter, say, 15-20 times to capture a collection of 'flats'. These can later be combined into one 'master' flat frame by your stacking software.

By the end of your imaging session you should have your raw images showing your chosen swathe of the Milky Way as well as a set of darks and a set of flat frames. All these can then be loaded into astronomical stacking software, which will calibrate and combine them to create a single, stacked image that can be further processed and enhanced in software like Photoshop or GIMP.

And don't worry if by the end of October you're only just getting the hang of wide-field Milky Way imaging. With winter looming, there will soon be a new array of targets high in the sky at a sociable hour for you to test your newfound skills on. 





# 50 YEARS OF APOLLO

## APOLLO 7

50 years ago, NASA launched its first crewed test of the Apollo programme. While the mission went smoothly for the module, the same could not be said for the crew. **Elizabeth Pearson** looks back at the mission



### MISSION BRIEF

**Launch date:** 11 October 1968

**Launch location:** Launch Complex 34, Cape Kennedy, Florida

**Orbits:** 163

**Furthest distance travelled from Earth:** 301km

**Duration:** 10 days, 20 hours, 9 minutes

**Return date:** 22 October 1968

**Main goals:** Test docking procedure; test engine system; assess effects of long duration spaceflight

**Firsts:** Crewed Apollo mission; live television broadcast from space

**Typical menu:** Pot roast, Canadian bacon and apple sauce, sugar cookies and butterscotch pudding

NASA X 16

This October marks the 50th anniversary of Apollo 7, the programme's first crewed spaceflight. Over the 11-day mission, the crew tested the Apollo hardware while in the relative safety of low-

Earth orbit, practiced the manoeuvres that would be needed to land on the Moon and made the first ever live TV broadcast from space – all of them small steps on the giant leap towards the Moon.

From the outset of the mission, tensions were high. NASA had delayed crewed Apollo missions after a fire on 27 January 1967 had killed all three Apollo 1 astronauts. The Apollo team had spent the last 20 months performing safety evaluations and checks, until they were certain that not only could they land a man on the Moon, but also return him safely to the Earth.

Satisfied with their checks, NASA gave Apollo 7 the all clear, and on 11 October 1968 astronauts Walter M Schirra Jr, Donn F Eisele

“Where there is a will there is a way, and I will find a way to eat this fruit cocktail”  
– Walter Cunningham



▲ Apollo 7 launched on a Saturn IB SA-205 rocket from Cape Kennedy



◀ A technician called Apollo 7's partially opened fairings a "four-jawed, angry alligator", referencing Tom Stafford's comment during the Gemini IX mission that the Augmented Target Docking Adapter looked like an "angry alligator"

▼ Pre-cold, pre-mutinous crewmembers



and R Walter Cunningham launched into orbit from Cape Kennedy.

The main goal of the mission was to test the Apollo hardware in action. The first big test came only a few hours after launch, when the crew simulated docking with a lunar landing module. In subsequent Apollo missions, the Lunar Module would be stored behind the part of the spacecraft where the astronauts lived and worked, called the Command Service Module (CSM). Before the astronauts could land on the Moon, they would first have to detach from the CSM, turn around, dock with the lander and pull it out of its housing.

Apollo 7 needed to practise this, but as they didn't have a Lunar Module they instead simulated the

manoeuvre using a test rig. Things didn't start off well, though, as the panels covering the rig didn't fully open. However, thanks to Lunar Module pilot Walter Cunningham's expert flying skills, they managed to make the docking.

## Firing up the CSM's engines

The crew also tested the engines that would propel the CSM towards the Moon, put it into orbit and then allow it to return to Earth. Without these engines, reaching the Moon was impossible. When the crew first test fired the engine, the kick was so powerful Schirra yelled out, "Like a bomb, yabadabadoo! Great man! That's like a ride and a half down there gang." They tested the engines a total of eight times with no major problems.

Afterwards the crew continued to drift from the second stage of their Saturn IB until they were 120km away. At this point they turned around and rehearsed rendezvousing with the stage. A similar manoeuvre would be vital for the future Command Module pilots left in orbit around the Moon, who would have to pick up the lunar ascent stage when the moonwalkers returned from the surface.

With that test successfully completed, the big engineering tasks were all out the way, and the team settled in for the remaining nine days of the mission. Apollo 7 was the longest spaceflight undertaken up to that point, and the endeavour would help to flag up not only hardware issues, but problems with how the missions were run.

Things started well. The crew could easily move around the cabin, which was far larger than either the previous Mercury or Gemini spacecraft, and fears that their motion would destabilise the module proved unfounded.

The crew did encounter a few minor problems. The astronauts had brought too much sweet food. Though rich in calories, they quickly went off the taste, and advised future Apollo astronauts to ►

## THE ASTRONAUTS



### Commander: Walter M Schirra Jr

By the time of his Apollo 7 flight Schirra was already a space veteran. He was one of the original Mercury Seven astronauts and had flown in both the Mercury and Gemini programmes. After Apollo 7 he retired from NASA, and became a news consultant for the subsequent Apollo missions. He died in 2007, aged 84.



### Command Module pilot: Donn F Eisele

Before joining NASA, Eisele was a test pilot with the US air force with over 4,200 hours of flying time under his belt. He was originally selected to pilot Apollo 1, but dislocated his shoulder during training and was reassigned to Apollo 7. He left NASA in 1972 to become country director of the Peace Corp in Thailand and died in 1987, aged 57.



### Lunar Module pilot: R Walter Cunningham

Cunningham was a fighter pilot with the US Marine Corps and has a degree in physics. Though there was no lunar module on Apollo 7, he conducted the tests that would allow future missions to operate a lander. After leaving NASA he became a businessman, investor and writer. He currently works as a radio talk show host.



◀ Tuamotu Archipelago in the South Pacific, taken by the Apollo 7 spacecraft during its 141st orbit

► choose ham and soup over butterscotch pudding. Additionally, the fuel cells overheated, though not dangerously so, and the fans in the living space were so noisy the crew had to turn them off. These were all minor issues and quickly fixed. But there would be some trickier challenges involving one of the most vulnerable and unpredictable components of the mission – the crew itself.

On the first day in orbit, mission commander Schirra developed a cold. Within the sealed environment of the Apollo craft, it wasn't long before the other two astronauts caught it too. Without gravity to help clear out their sinuses, the crew soon found themselves uncomfortably stuffed up. Sick, and with a demanding schedule

“We all three have our colds. I asked for an hour and a half sleep for each of us last night, and that apparently was ignored”  
– Walter Schirra

that prevented them getting enough sleep, the crew became irritable and bickered constantly with ground control.

The first signs of trouble centred around what was supposed to be the first ever live television broadcast from space. Before flying, mission commander Schirra had requested the broadcasts be removed from what was an already crowded schedule, but NASA felt obliged to show the US public where their tax dollars were going. When the time for the first broadcast came around, Schirra refused to turn the cameras on, stating, “We do not have the equipment out... we have not eaten at this point. At this point, I have a cold. I refuse to foul up our time lines in this way.”

When the broadcast did eventually go ahead two days later on 14 October, the astronauts smiled throughout, showing no sign of the strife going on behind the scenes.

## Pressure points

The biggest argument came towards the end of the mission. The crew members were concerned that their colds could stop their ears adapting to the changes in pressure during re-entry, and wanted to be able to blow their noses to prevent their eardrums

bursting. While previous spacesuits had come with a visor, the Apollo suits had full domes that needed to be completely removed every time someone wanted to blow

# MISSION TIMELINE

**11 Oct, 15:02 GMT**  
Apollo 7 lifts off on top of a Saturn IB, a smaller version of the rocket that would take future crews to the Moon.

**11 Oct, 15:05 GMT**  
First stage runs out of fuel and drops away. Liquid hydrogen-fuelled second stage (S-IVB) takes over.

**11 Oct, 15:13 GMT**  
Apollo 7 reaches an orbital path of 227-285km.

**11 Oct, 17:57 GMT**  
The Command Service Module separates from S-IVB, turns around and simulates docking with a Lunar Module.

**12 Oct, 17:27 GMT**  
The engines that would take future Apollo missions to the Moon are given a test fire.

**12 Oct**  
Apollo 7 drifts 120km away from the S-IVB, then returns in a rehearsal for finding a lander returning from the lunar surface.

**14 Oct, 14:45 GMT**  
The first live TV broadcast from space begins after a two-day delay caused by crew tensions.

**22 Oct, 10:56 GMT**  
The crew re-enters Earth's atmosphere.

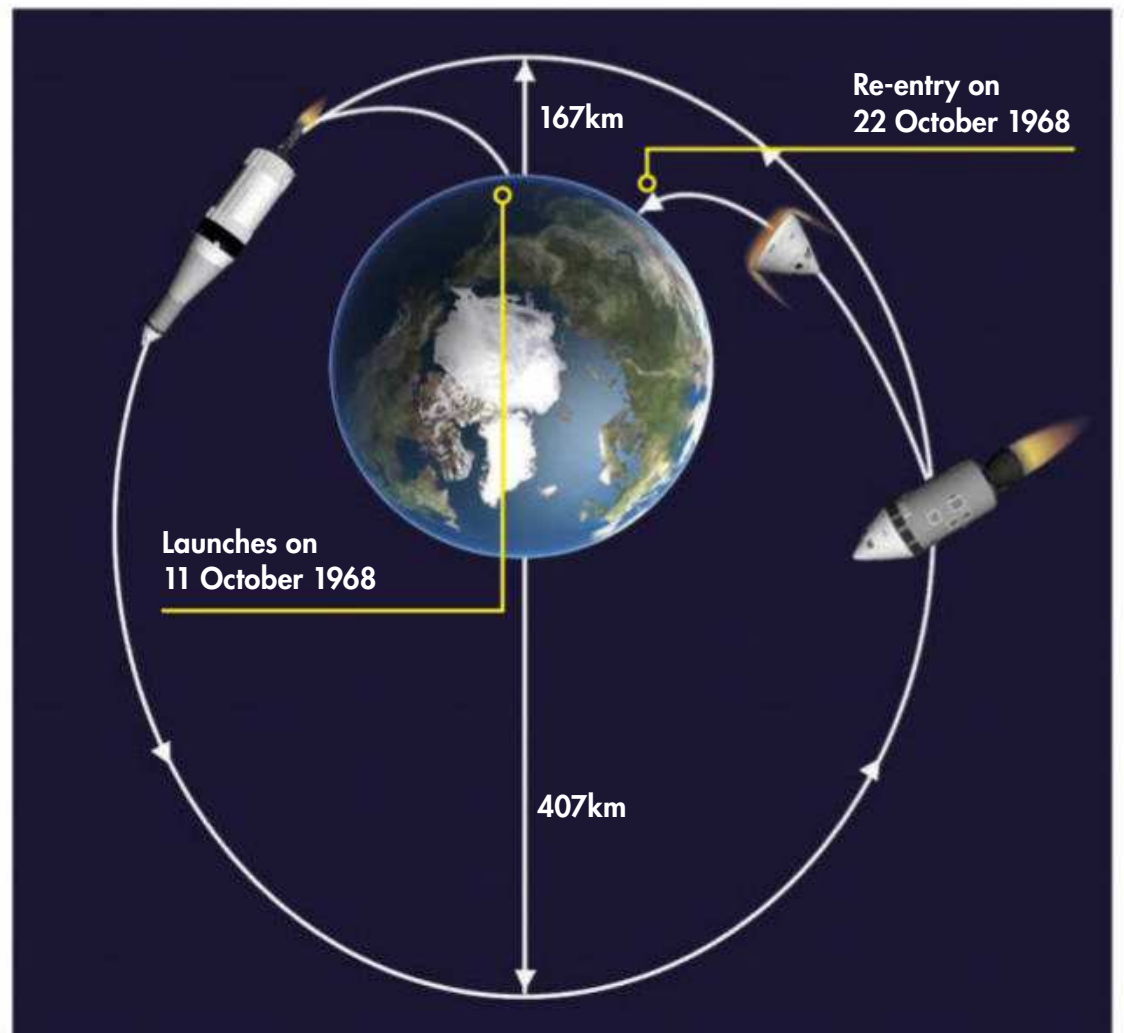
**22 Oct, 11:11 GMT**  
Apollo 7 splashes down in the Atlantic Ocean.



▲ Schirra (left) and Cunningham (right) were both suffering from colds by the end of the mission, making them grouchy

► NASA's original flight plan for the Apollo 7 mission. In reality the orbit varied between 227km and 163km

▼ The crew gamely smiled for the first live TV broadcast from space despite their issues with ground control



“The only thing we’re concerned about is the landing. We couldn’t care less about the re-entry. But it’s your neck and I hope you don’t break it” – Capcom

their nose. As they would be fully suited up during re-entry, including cumbersome gloves, this was an extremely awkward procedure, so the astronauts decided to forgo their helmets.

Fearing that anything less than a perfect landing could cause an injury, ground control ordered them to wear their helmets. The crew ignored them. Acknowledging that there was nothing they could do to force the astronauts to comply, a flight controller told the crew, “It’s your neck and I hope you don’t break it.”

In the end re-entry and splashdown went smoothly, with neither burst eardrums nor broken necks. The

▼ Schirra exiting the Command Module after splashdown in the Atlantic



‘mutiny’ made NASA understand the importance of giving future astronauts a decent menu and enough time to rest, but the insubordination of the Apollo 7 crew ensured that none of them would ever fly in space again.

Despite these setbacks, the mission was a success. The Apollo hardware worked. The stage was set and the Apollo programme was finally ready to leave the safety of Earth and head for the Moon. **S**



#### ABOUT THE WRITER

Dr Elizabeth Pearson is BBC Sky at Night Magazine's news editor. She gained her PhD in extragalactic astronomy at Cardiff University

The crew aboard USS Essex on 22 October 1968 just after being hoisted from the sea





Santiago, Chile



Casablanca Valley, Chile



Sacred Valley, Cusco, Peru

## Experience the wonders of Peru & Chile on this once in a lifetime eclipse tour!

Omega Holidays has been running astronomy themed breaks for over 20 years with the help of expert astronomers, and we are delighted to bring you this thrilling adventure to see the total solar eclipse in Chile 2019.

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wine tasting at a vineyard in the **Casablanca Valley**, an area well known for its white wines and Pinot Noir.

Of course the highlight of this once in a lifetime trip will be the chance to see the eclipse as it cuts a path across the **Atacama Desert**. The total phase of this eclipse is occurring when the Sun and Moon are only about 14 degrees in altitude above the horizon (at our observing site) and that should make for a particularly awe-inspiring view sitting over the spectacular Chilean landscape.

This tour promises to be a highlight of the 2019 calendar and we hope you can join us for this truly memorable experience.

### Exclusive Discount

We're offering an **exclusive £200pp\* discount** off our Eclipse breaks if you **book by 23 October 2018**. Simply call us and quote: **CHILE19** or use the same quote code at the checkout online.

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### FEATURED VISIT - MACHU PICCHU, PERU

On this excursion we visit the sacred city of Machu Picchu in Peru, including a guided tour as well as time to explore the site on your own at leisure. Believed to be built around 1450-1460 as an estate for the great Inca ruler Pachacutec Inca Yupanqui, Machu Picchu was eventually abandoned due to Spanish Conquests and the collapse of the Incan Empire.

Much Inca architecture was designed and built to assist worship of the Sun, with the Sun God, Inti, being the second most important god in Inca culture. Inti was said to control warmth, light and sunshine necessary for agriculture. It was by his will that crops grew and animals thrived.

The Inca could not predict solar eclipses and when one occurred, they were greatly troubled by it. They believed an eclipse meant that Inti was angry or displeased with them and so the Inca people would seek to appease him with ritual sacrifice.

Fortunately today we are able to predict when solar eclipses occur so instead we can simply relax and enjoy this natural spectacle!

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- ✓ Tour accompanied throughout by astronomer Pete Lawrence

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*Omega*

# The Sky Guide October

This month lunar libration will favourably reveal the 181km crater Einstein, which is located on the Moon's extreme western edge as seen from Earth

## GET THE SKY GUIDE WEEKLY

For weekly updates on what's best to observe, sign up to our email newsletter: [www.skyatnightmagazine.com/iframe/newsletter-signup](http://www.skyatnightmagazine.com/iframe/newsletter-signup)

### ABOUT THE WRITERS

Pete Lawrence is an astronomer and astro imager who presents *The Sky at Night* monthly on BBC Four



PETE LAWRENCE

Stephen Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 60



### RED LIGHT FRIENDLY

To preserve your night vision, this Sky Guide can be read using a red light under dark skies



### DON'T MISS...

- ♦ Jupiter and Mercury together in the twilight
- ♦ 21P/Giacobini-Zinner has a close encounter with old friends
- ♦ The Draconid meteor shower – can we expect a strong one?



# OCTOBER HIGHLIGHTS

Your guide to the night sky this month



## THURSDAY

# 4

In the early hours a 29%-lit waning crescent Moon will sit 3° from the open cluster M44, the Beehive Cluster. This presents a great opportunity for astrophotography and a chance to compare the size of both objects using a wide-field instrument, such as binoculars.

## FRIDAY

# 5

Venus is reasonably well separated from the Sun at the start of October but poorly positioned in the evening, setting with our star. If you have the means to locate it during the day (shield your eyes against the Sun!) it's currently in a slender and rather elegant crescent phase.

## WEDNESDAY

# 10

Tonight is predicted to be the peak of activity for the Southern Taurid meteor shower.



## SUNDAY

# 14

This evening it's the turn of Saturn to appear close to the Moon. Tonight's meeting has the ringed planet 4.7° from a 31%-lit waxing Moon at 19:00 BST (18:00 UT). Catch them low above the south-southwest horizon.

## THURSDAY

# 18

It's Mars that gets a lunar visit this evening with the mag. -0.9, orange-hued planet visible 3° from the 68%-lit waxing gibbous Moon at 19:00 BST (18:00 UT).



## SUNDAY

# 21

This evening sees the peak of the Orionid meteor shower. Unfortunately, this year a bright Moon will compromise our view.

## WEDNESDAY

# 24

This evening's full Moon will reveal the subject of this month's Moonwatch article, the libration-zone crater Einstein. Turn to page 58 to learn more.

Also, Uranus reaches opposition.

## FAMILY STARGAZING - 9 OCT



The Andromeda Galaxy is one of astronomy's 'wow' objects. Locate it from the W-shaped Cassiopeia. Imagine the right half of the W as an arrow. Follow its direction to arrive at Mirach (Beta (β) Andromedae). Head back towards the W veering slightly right to locate dimmer Mu (μ) Andromedae. Keep going to locate even dimmer Nu (ν) Andromedae. The faint fuzzy oval of the Andromeda Galaxy, M31, sits slightly above and right of Nu. This is the furthest object visible with the naked eye under normal dark sky conditions, 2.5 million lightyears away.

[www.bbc.co.uk/cbeebies/shows/stargazing](http://www.bbc.co.uk/cbeebies/shows/stargazing)



## SATURDAY

# 27

The bright orange star that appears 4° to the right of this evening's rising 86%-lit waning gibbous Moon is Aldebaran (Alpha (α) Tauri), the brightest star in the constellation of Taurus.





## MONDAY

**8** The Draconid meteor shower is predicted to peak at around midnight to 01:00pm on Tuesday morning. Will a close pass of its parent comet, 21P/Giacobini-Zinner make any difference? Turn to page 52 to find out. A new Moon means prospects for viewing the shower are excellent.

## TUESDAY

**9** The Moon is new today, leaving the night sky good and dark. This is a great time to try out our Deep Sky Tour on page 62. This month we're looking at some of the objects at the eastern end of the W-shape in Cassiopeia. It's also a good time to look for the Andromeda Galaxy, M31.

## THURSDAY

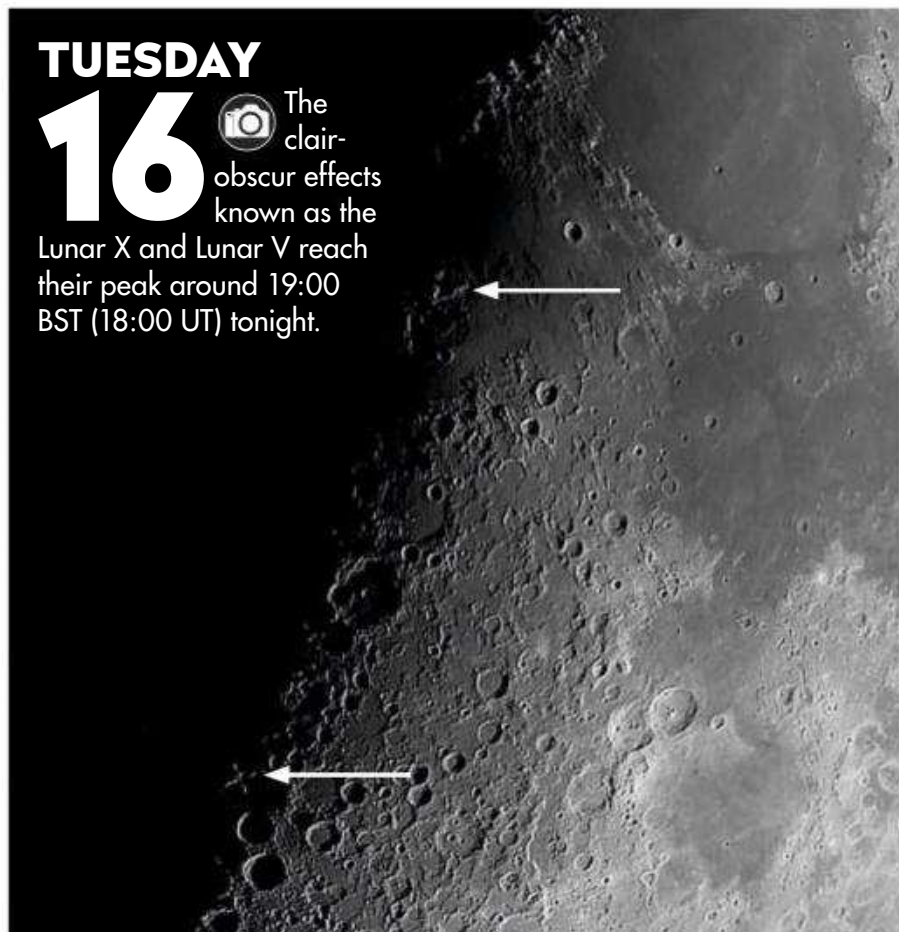
**11** Jupiter appears just 4.5° from this evening's 7%-lit waxing crescent Moon. See both objects in the evening twilight low towards the southwest horizon around 18:30 BST (17:30 UT).

## FRIDAY

**12** Comet 21P/Giacobini-Zinner is located a little over 6° to the east of Sirius (Alpha (α) Canis Majoris) at present. At mag. +8.3 it should be a binocular object.

## TUESDAY

**16** The clair-obscure effects known as the Lunar X and Lunar V reach their peak around 19:00 BST (18:00 UT) tonight.



## FRIDAY

**26** Venus reaches inferior conjunction today, passing a close 6.3° to the south of the Sun. After this it technically becomes a morning object.

## SUNDAY

**28** At 02:00 BST (01:00 UT), daylight savings in the UK officially comes to an end and the clocks need to be set back by one hour to GMT (UT).

## TUESDAY

**30** Mercury and Jupiter are just 3.5° apart, low in the southwest after sunset. Mag. -0.1 Mercury will be very low and close to the horizon making this a challenging pair to see.

## WEDNESDAY

**31** If you have a good southern horizon, look for comet 46P/Wirtanen, due south at 23:30 UT. At mag. +7.4 it should be a binocular object but being very low it will be tricky. The good news is that Wirtanen will start heading north to become a naked-eye object over the next few weeks.

## NEED TO KNOW

The terms and symbols used in *The Sky Guide*

### UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

### RA (RIGHT ASCENSION) AND DEC. (DECLINATION)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'.

### FAMILY FRIENDLY

Objects marked with this icon are perfect for showing to children

### NAKED EYE

Allow 20 minutes for your eyes to become dark-adapted

### PHOTO OPP

Use a CCD, planetary camera or standard DSLR

### BINOCULARS

10x50 recommended

### SMALL/MEDIUM SCOPE

Reflector/SCT under 6 inches, refractor under 4 inches

### LARGE SCOPE

Reflector/SCT over 6 inches, refractor over 4 inches



## GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit [http://bit.ly/10\\_Lessons](http://bit.ly/10_Lessons) for our 10-step guide to getting started and [http://bit.ly/First\\_Tel](http://bit.ly/First_Tel) for advice on choosing a scope.

# THE BIG THREE

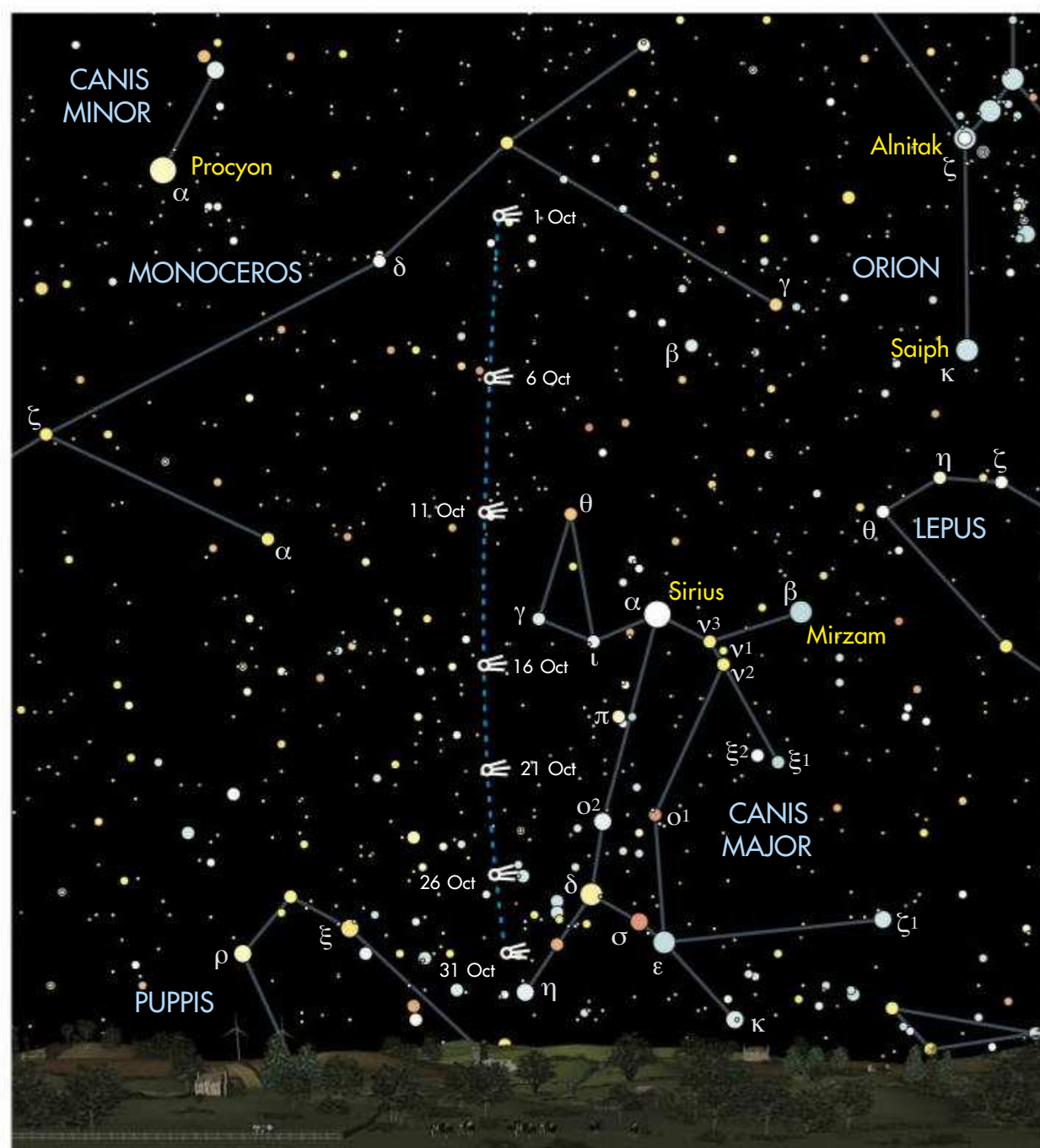
The three top sights to observe or image this month

## DON'T MISS

► Draconid meteors appear to originate near Nu (ν) Draconis

## Comet 21P/Giacobini-Zinner and the Draconid meteor shower

**WHEN:** As described, with the Draconids peaking on 8/9 October



▲ The path of 21P/Giacobini-Zinner for October, before it slips out of view over the horizon

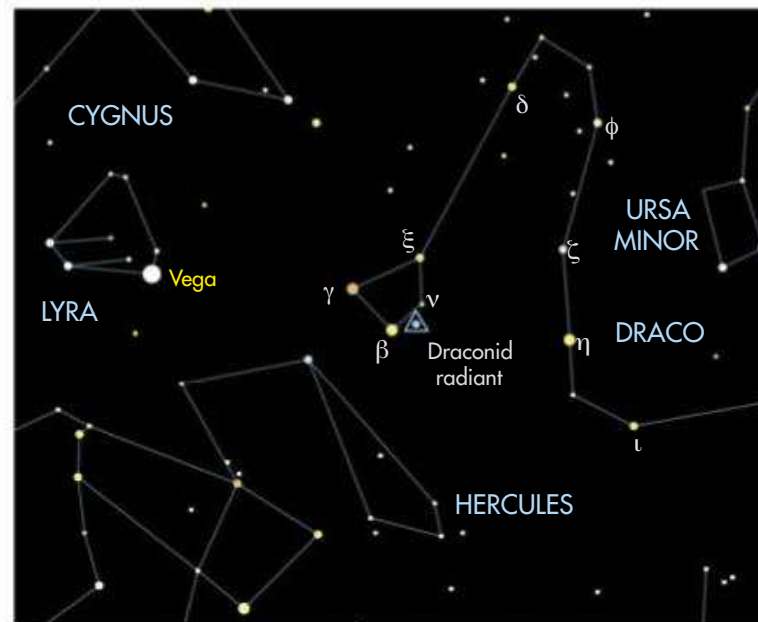


Time is running out to grab a view of comet 21P/Giacobini-Zinner. It reached mag. +7.0 last month as it tracked through Auriga and south through Gemini and into Monoceros. It was at perihelion on 10 September following a favourable close pass of Earth at a similar time, coming as near as 0.39AU or 58 million km of us.

21P is now fading as it continues south and October is your last chance to catch it for this tour before it slips below the UK's horizon.

At 01:00 BST (00:00 UT) on 1 October, mag. +7.6 Giacobini-Zinner will be a couple of degrees south and slightly west of mag. +4.5, 18 Monocerotis. Over the following days, it continues south, passing through eastern Canis Major. On the morning of 9 October it should be around mag. +8.1 and will be 3° east of mag. +4.1 Theta (θ) Canis Majoris.

Having dimmed slightly to mag. +8.4 by the morning of 13 October, the comet is in the region pointed to by extending a line from Mirzam (Beta (β) Canis



Majoris) to Sirius (Alpha (α) Canis Majoris) for about the same distance again.

Tracking further south and riding along the back of the Great Dog, the comet continues to dim. By the end of October, at magnitude +9.5, it is located close to Eta (η), Tau (τ) and Omega (ω) Canis Majoris, which form the Great Dog's tail. This region never gets high above the horizon as seen from the UK and represents the period when the comet will probably be lost from view.

As comets are quite fuzzy in appearance, the presence of a bright Moon affects visibility. Fortunately, the Moon will be out of the way for a large part of the month, permitting decent, dark sky views from 4-22 October.

In addition to the presence of 21P in our skies, its recent perihelion passage and close pass of Earth raises the question about whether it may enhance the Draconid meteor shower. This occurs when Earth passes through dust strewn around 21P's orbit.

Certainly, short-lived storm level activity was seen in 1933 and 1946 with lower yet significant outbursts over other years close to the parent comet's perihelion. ZHRs (Zenithal Hourly Rates) ranged from 20-500 or more meteors per hour over short periods.

This year, the peak of activity is expected on the night of 8/9 October. The enhancement to the Draconids' normal 10 meteors per hour ZHR is expected to be quite subtle, perhaps raising it to something in the range of 15-50. As ever with meteor showers, it's your observations that help refine these predictions and there's always the chance that something unexpected may happen.

# Comet 46P/Wirtanen brightens

**WHEN:** 6-18 October when Moon interference is lowest



South-moving comets seem to be the theme this month. While

21P/Giacobini-Zinner travels down the eastern side of Canis

Major, 46P/Wirtanen moves south into the constellation of Fornax, the Furnace.

However, unlike 21P, comet 46P is brightening. Don't be

fooled by its apparent poor positioning and direction. The comet continues to head south through October and into the start of November, but as we head through the main part of November it turns northeast, rapidly accelerating and brightening as it goes.

Consequently, if you can find it this month then you'll be well-prepared to observe it at its best later in the year, when Wirtanen is predicted to become a naked-eye comet. Spotting it now means you'll be ready for the transition and have a head start on those who only start trying to locate it when it brightens up.

It begins the month 5° south and slightly east of mag. +4.0 Upsilon (v) Ceti. Despite its very low UK position, its motion south is quite slow during October. It'll be 1° west of mag. +5.4 Pi (π) Fornacis

on the night of 13/14 October and by the end of the month will have tracked approximately 6° south of where it was on 1 October.

Wirtanen begins October at mag. +9.7 but is expected to have brightened to +8.7 by the time it passes Pi Fornacis. By the end of the month, the comet is predicted to be at mag. +7.4; an overall brightening of 2.3 magnitudes throughout October.

The region of sky Wirtanen will be travelling through is best seen when at its highest position in the sky, due south. This occurs at 02:30 BST (01:30 UT) on 1 October, 01:30 BST (00:30 UT) on 15 October and 23:30 UT at the end of the month. Good luck with your comet hunt but if you don't find it, don't despair. Comet 46P/Wirtanen is just about to start the main show!

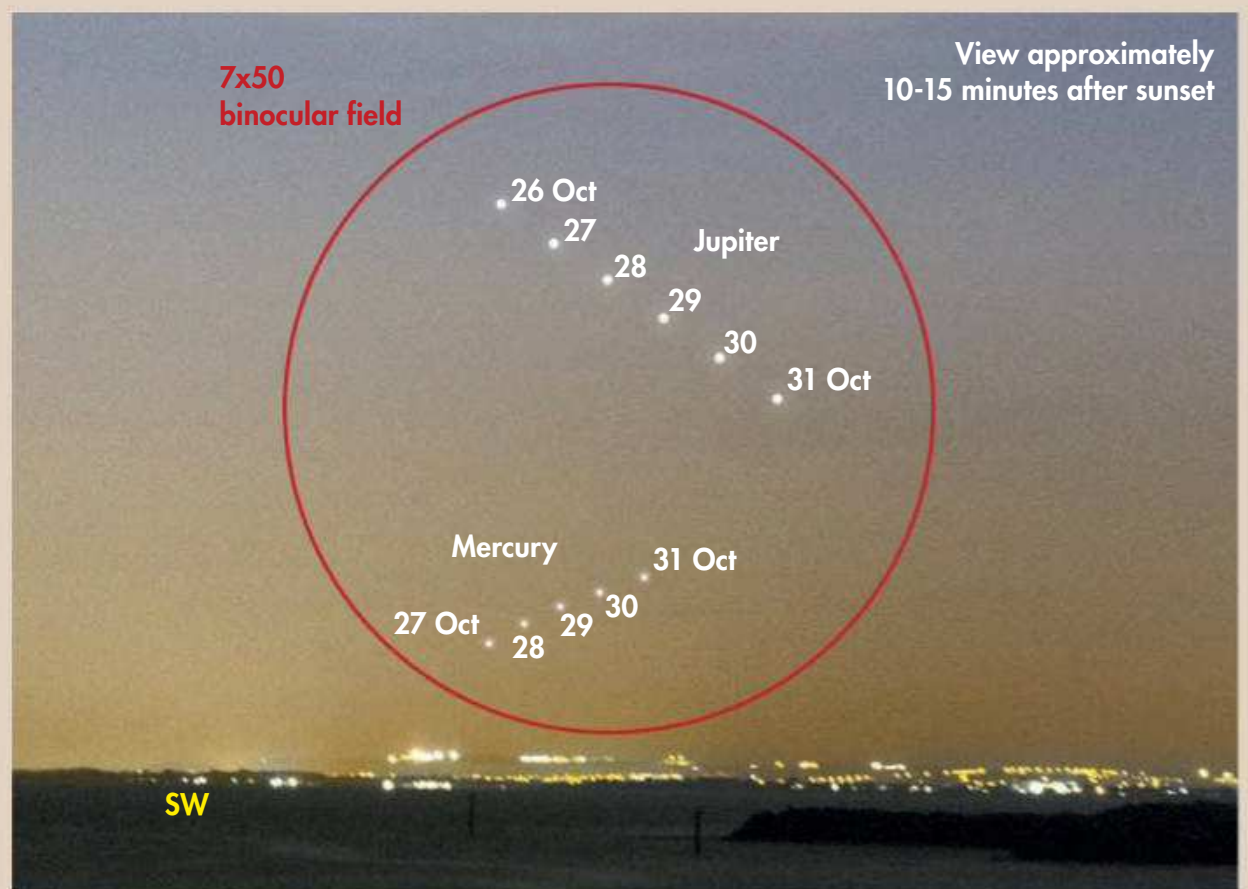
## A challenging Mercury-Jupiter conjunction

**WHEN:** 26-31 October, approximately 10-15 minutes after sunset



If you're able to see the bright, mag. -1.6 planet Jupiter low in the southwest after sunset at the beginning of the month, try and stay with it over subsequent evenings. A lovely 8%-lit waxing crescent Moon is located 4.3° from Jupiter on the evening of 11 October and this should make the planet easier to find. Jupiter will be positioned below and left of the Moon's crescent as seen from the UK. If you miss the close pairing on the 11th, the now 14%-lit crescent Moon sits 10° above and left of Jupiter on the evening of 12 October.

All the while, the Solar System's innermost planet, Mercury, will be slowly appearing to separate from the



Sun and heading for a close, yet tricky to see, conjunction with Jupiter at the end of the month. On the evening of 28 October, mag. -0.2 Mercury will lie 3° directly below Jupiter. Place Jupiter at the top of a binocular field of view and you should see Mercury near the centre.

Both planets remain relatively close together between 26-31 October, with Mercury remaining at a similar magnitude across these evenings. See if you can catch both planets before Jupiter finally disappears for the current period of observation.

# THE NORTHERN HEMISPHERE IN OCTOBER

## KEY TO STAR CHARTS

- Arcturus
- STAR NAME
- PERSEUS
- CONSTELLATION NAME
- 
- GALAXY
- 
- OPEN CLUSTER
- 
- GLOBULAR CLUSTER
- 
- PLANETARY NEBULA
- 
- DIFFUSE NEBULOSITY
- 
- DOUBLE STAR
- 
- VARIABLE STAR
- 
- THE MOON, SHOWING PHASE
- 
- COMET TRACK
- 
- ASTEROID TRACK
- 
- STAR-HOPPING PATH
- 
- METEOR RADIANT
- 
- ASTERISM
- 
- PLANET
- 
- QUASAR
- STAR BRIGHTNESS:
- 
- MAG. 0 & BRIGHTER
- 
- MAG. +1
- 
- MAG. +2
- 
- MAG. +3
- 
- MAG. +4 & FAINTER



MILKY WAY

## WHEN TO USE THIS CHART

**1 OCTOBER AT 01:00 BST**  
**15 OCTOBER AT 00:00 BST**  
**31 OCTOBER AT 22:00 UT**

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

## HOW TO USE THIS CHART



- 1. HOLD THE CHART** so the direction you're facing is at the bottom.
- 2. THE LOWER HALF** of the chart shows the sky ahead of you.
- 3. THE CENTRE OF THE CHART** is the point directly over your head.

## SUNRISE/SUNSET IN OCTOBER\*

	DATE	SUNRISE	SUNSET
	1 Oct 2018	07:11 BST	18:47 BST
	11 Oct 2018	07:29 BST	18:23 BST
	21 Oct 2018	07:48 BST	18:01 BST
	31 Oct 2018	07:07 UT	16:40 UT

## MOONRISE IN OCTOBER\*

	MOONRISE TIMES
	01 Oct 2018, 22:35 BST      17 Oct 2018, 15:44 BST
	05 Oct 2018, 01:57 BST      21 Oct 2018, 17:25 BST
	09 Oct 2018, 07:24 BST      25 Oct 2018, 18:47 BST
	13 Oct 2018, 12:22 BST      29 Oct 2018, 20:25 UT

\*Times correct for the centre of the UK

## LUNAR PHASES IN OCTOBER

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				





# THE PLANETS

## PICK OF THE MONTH

### Mars

**Best time to see:** 15 October,  
20:30 BST (19:30 UT)

**Altitude:** 17°

**Location:** Capricornus

**Direction:** South

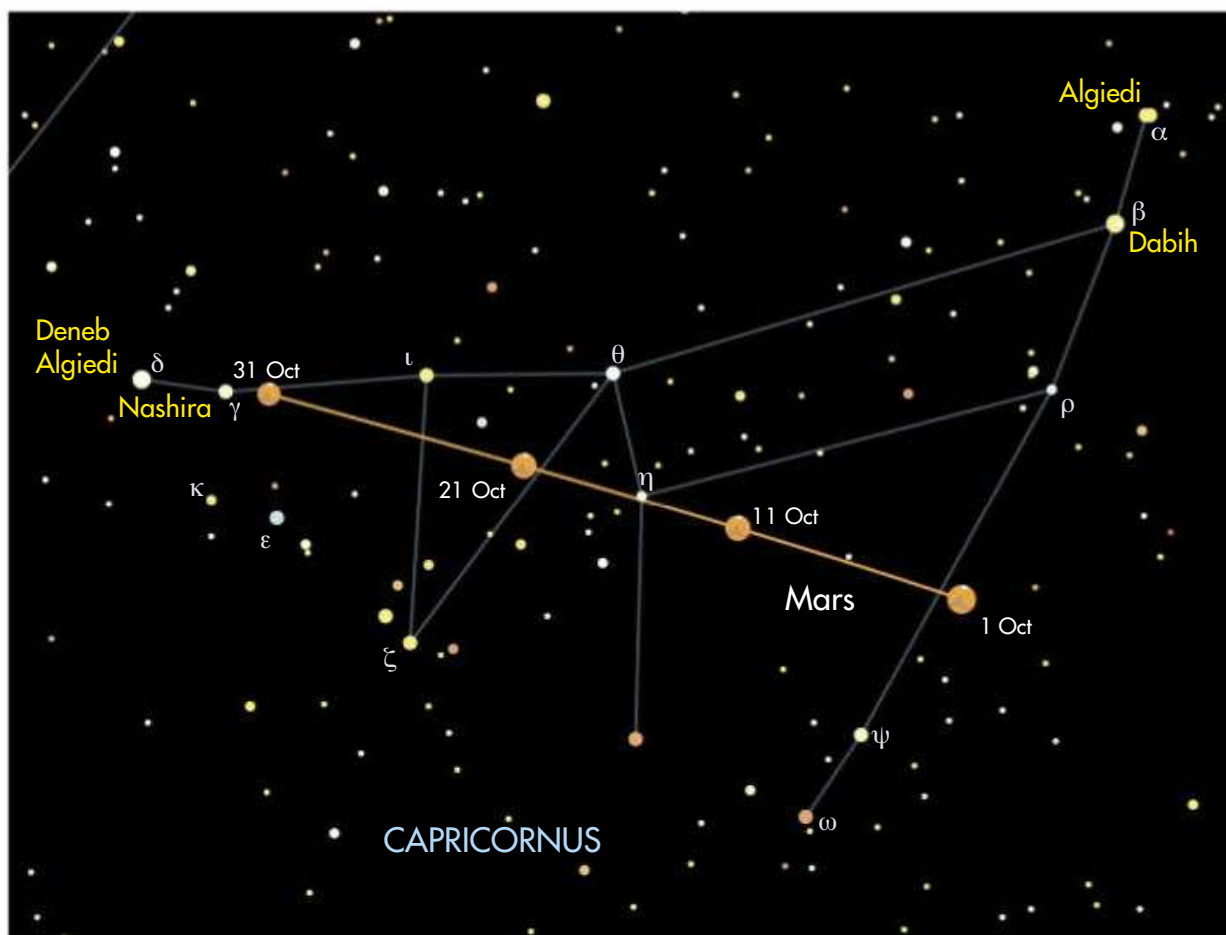
**Features:** Dark markings, polar caps

**Equipment:** 150mm or larger

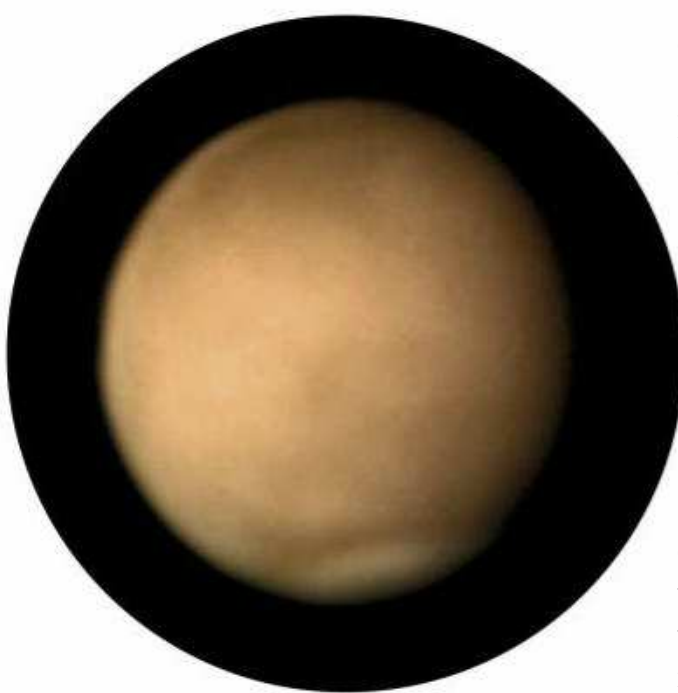
Mars is an evening object in Capricornus at the start of October, looking like a bright orange star at mag.  $-1.3$ . Through a telescope it presents a 15 arcsecond disc, large enough to show some of the more prominent surface features through the eyepiece. By the middle of October, Mars will have moved to sit right at the middle of the triangular midsection of Capricornus.

The planet is slowly gathering altitude and on 15 October reaches 17° altitude as seen from the centre of the UK. Through a telescope, Mars is shrinking and by 15 October appears just 13 arcseconds across. It's dimming too, dropping to mag.  $-1.0$  by the middle of the month. On 16 October, Mars appears to sit 2 arcminutes from mag.  $+4.8$  Eta ( $\eta$ ) Capricorni, before passing 2.5° south of mag.  $+4.0$  Theta ( $\theta$ ) Capricorni on 17 October, 1.3° south of mag.  $+4.3$  Iota ( $\iota$ ) Capricorni on 25 October and 4.7° north of mag.  $+3.8$  Zeta ( $\zeta$ ) Capricorni on 27 October. A waxing gibbous Moon sits nearby on 17 and 18 October.

By the end of October, Mars appears close to the pair of stars marking the



▲ As Mars travels through Capricornus during October it dims from mag.  $-1.3$  to mag.  $-0.6$



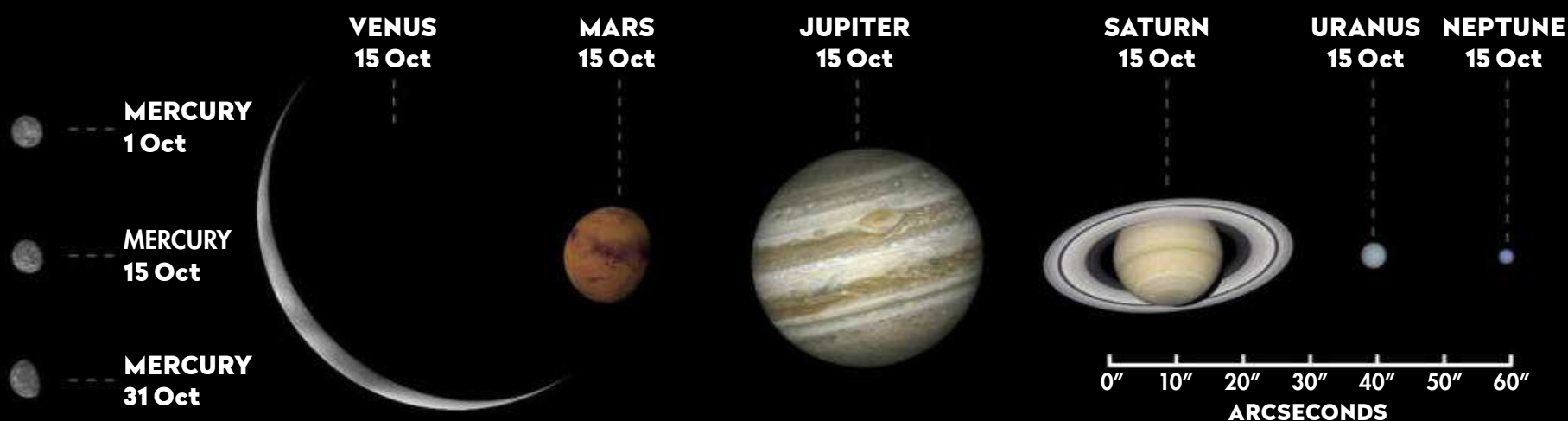
▲ Mars imaged from the UK on the morning of 26 June – many of its dark features are hidden by a dust storm that still raged in August

eastern extent of Capricornus; Gamma ( $\gamma$ ) Capricorni and Delta ( $\delta$ ) Capricorni. It now attains an altitude of 20° from the centre of the UK, twice what it managed when at opposition back in July. On 31 October Mars appears at mag.  $-0.6$  with an 11 arcsecond disc.

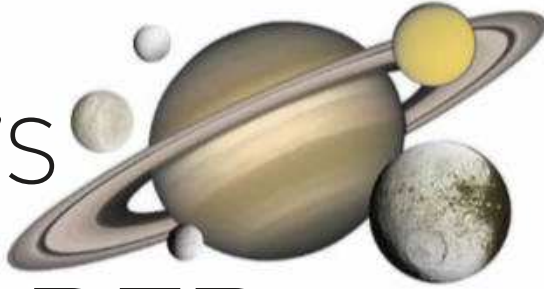
In June, a number of dust storms whipped their way across the Martian sphere, diminishing the appearance of many of the dark markings that usually feature on Mars's globe. The primary cause of these storms was Mars being close to perihelion, the closest point in its orbit to the Sun. They proved remarkably resistant through August, extending NASA's Opportunity Mars rover's radio silence to over two months. Will they have subsided by October? Only time will tell.

## THE PLANETS IN OCTOBER

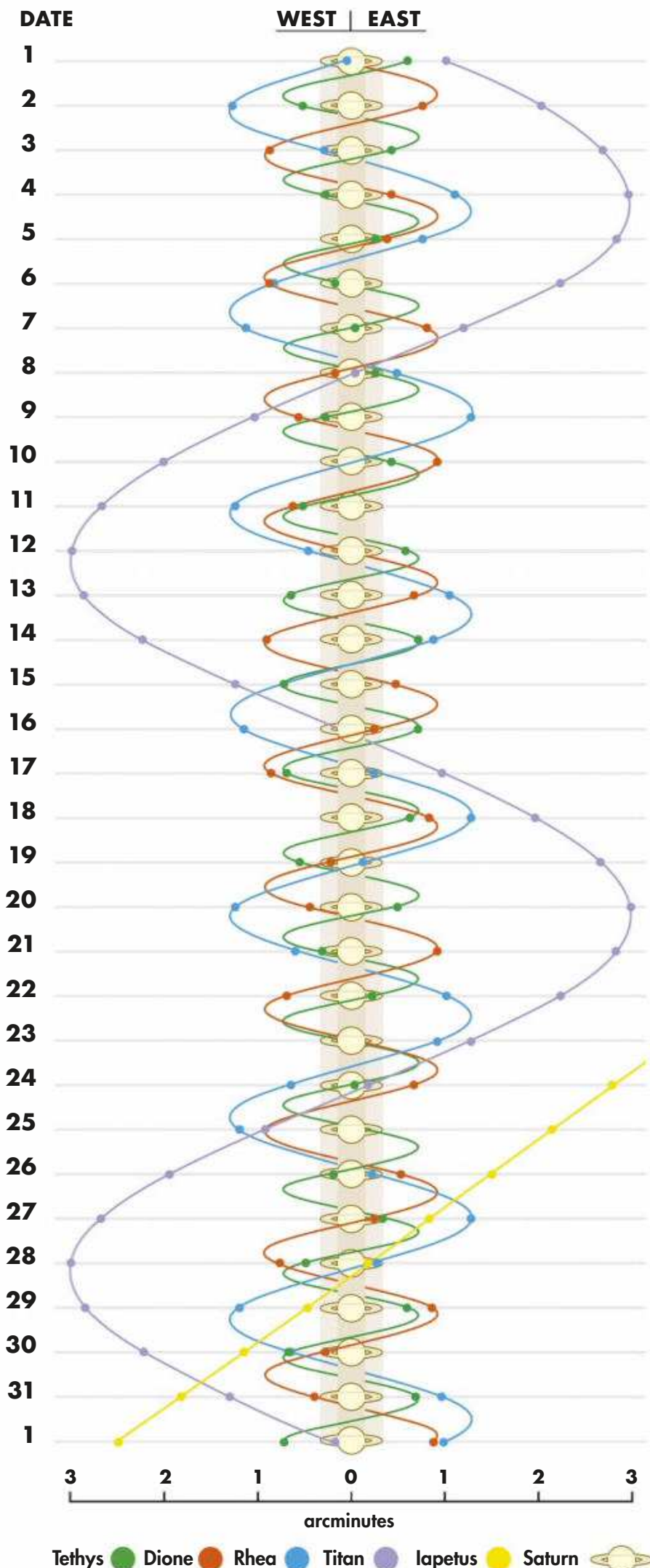
The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



# SATURN'S MOONS OCTOBER



Using a small scope you'll be able to spot Saturn's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



## Mercury

Mercury sets very soon after the Sun all month and is difficult to see. Your best bet is the end of October, when it's close to Jupiter and reasonably well separated from the Sun.

## Venus

**Best time to see:** 31 October, 20 minutes before sunrise

**Altitude:** 0.5° (very low)

**Location:** Virgo

**Direction:** East-southeast

Despite a decent separation of 32° from the Sun at the start of October, Venus sets with the Sun making it impossible to see in the twilight. The best views are to be had during the day when the Sun is up and Venus appears as a magnificent crescent. On 1 October, Venus appears 46 arcseconds across and 16% illuminated. By the middle of October it's 57 arcminutes across and 4% lit. Inferior conjunction occurs on 26 October when it will line up with the Sun on the closest part of its orbit to Earth. It'll be 6.25° south of the Sun at this time. It re-emerges into the morning sky rapidly, and by 31 October its mag. -4.0 dot will be seen low above the southeast horizon just before sunrise.

## Jupiter

**Best time to see:** 1 October, 19:30 BST (18:30 UT)

**Altitude:** 5° (low)

**Location:** Libra

**Direction:** Southwest

Jupiter is low in the southwest as darkness falls, setting just after 20:00 BST (19:00 UT) at the start of the month. A thin, 7%-lit waxing crescent Moon lies nearby on 11 October. Jupiter will be a challenging object close to Mercury at the end of the month.

## Saturn

**Best time to see:** 1 October, 20:50 (19:50 UT)

**Altitude:** 12°

**Location:** Sagittarius

**Direction:** South-southwest

Saturn is a low evening object

visible west of south as darkness falls at the start of October. A waxing crescent Moon lies nearby on the evening of 14 October. The planet dims from mag. +0.9 to +1.0 throughout the month.

## Uranus

**Best time to see:** 25

October, 00:55 BST

(24 October 23:55 UT)

**Altitude:** 48°

**Location:** Aries

**Direction:** South

Uranus is at opposition on 24 October. At mag. +5.7 Uranus is theoretically on the threshold of naked-eye visibility from a dark location. A full Moon joins Uranus on opposition night, 7° east-southeast of the planet.

Binoculars show Uranus as a star-like dot while a small telescope will reveal its green colour. A magnification of 100-150x shows Uranus as a disc. Being so distant, this planet doesn't give up its secrets easily and it takes a large telescope or an imaging setup to stand a chance of showing any form of detail on its globe. This normally takes the form of subtle banding.

From central UK, Uranus attains an altitude of 48°, lifting it above the turbulent atmosphere close to the horizon and affording a good opportunity for a stable view. Currently, it's close to the V-shaped trail of stars in Pisces but technically it's in Aries.

## Neptune

**Best time to see:** 1 October, 23:30 BST (22:30 UT)

**Altitude:** 30°

**Location:** Aquarius

**Direction:** South

Neptune was at opposition last month and remains well positioned through October. At mag. +7.8 it requires optical assistance to see. A telescope reveals its lovely blue colour and tiny 2.2 arcsecond disc. It's currently located close to mag. +3.7 Lambda (λ) Aquarii.

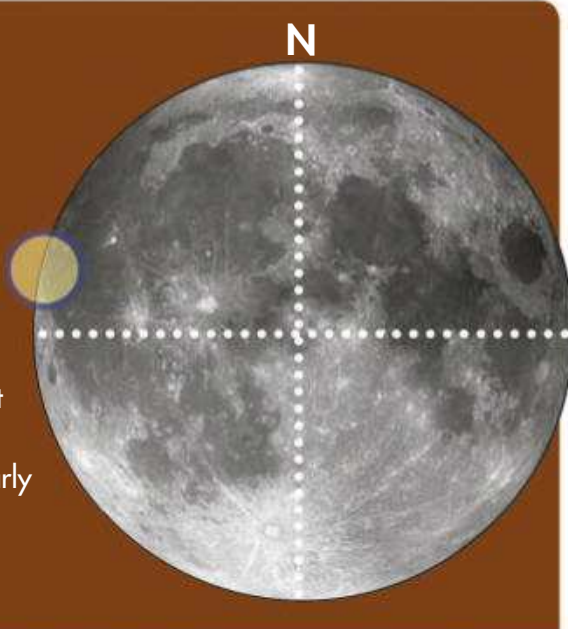
## YOUR BONUS CONTENT

Planetary observing forms

# MOONWATCH

## Einstein

**Type:** Walled plain  
**Diameter:** 181km  
**Longitude/latitude:**  
 88.7° west, 16.6° north  
**Age:** Undetermined  
**Best time to see:**  
 Immediately before full  
 Moon or six days after last  
 quarter with compatible  
 libration. View from the early  
 hours of 24-29 Oct  
**Minimum equipment:**  
 10x binoculars



A quick glance at **Einstein's** longitude is enough to indicate that this is a tricky feature to view and image. At 88.7° west, it would usually sit right on the geometric limb as seen from Earth assuming the line of 0° longitude ran down the centre of the Moon all the time. In reality this is not the case as lunar libration – a rocking and rolling motion caused by the tilt and elliptical nature of the Moon's orbit – regularly swings the position of the zero longitude line east and west slightly. As a consequence, libration rotates Einstein into view at certain times and out of view at others.

This means that features like Einstein in both the east and west libration zones are difficult to observe well. Visibility in these zones only works well when the lighting is oblique and the lunar terminator fairly nearby. In addition, despite Einstein's vast 181km diameter, its proximity to the limb means we're seeing it from an extreme angle, so it appears very thin.

Einstein is a large crater best described as a walled plain. From Earth we get to see the inner slopes of its western rim and the outer slopes of its eastern rim. A few details can be seen on its slightly domed floor. As well as a few smaller craters, there's one whopping example known as **Einstein A**. This is fairly sizeable itself with a diameter of 51km. Like Einstein, we only get to see the

inner slopes of Einstein A's western rim and the outer slope leading up to its eastern wall. The outer slope of Einstein A is of course, the floor of Einstein.

Our foreshortened view of Einstein tends to give the

impression that its rim is fairly intact but images from lunar orbit tell a different story. From a more overhead perspective, the rim is amazingly pock-marked with smaller impact craters. The concentration of the impacts here is so high, it's quite astonishing how disguised they are under low angle viewing.

Einstein occupies an interesting region of the Moon that bears the brunt of ejecta fallout from the impact that formed **Mare Orientale**, a massive 300km diameter, concentric-ringed impact basin located further to the south. A lot of the fresh craters in the Einstein region were probably secondary impacts from that which formed Mare Orientale.

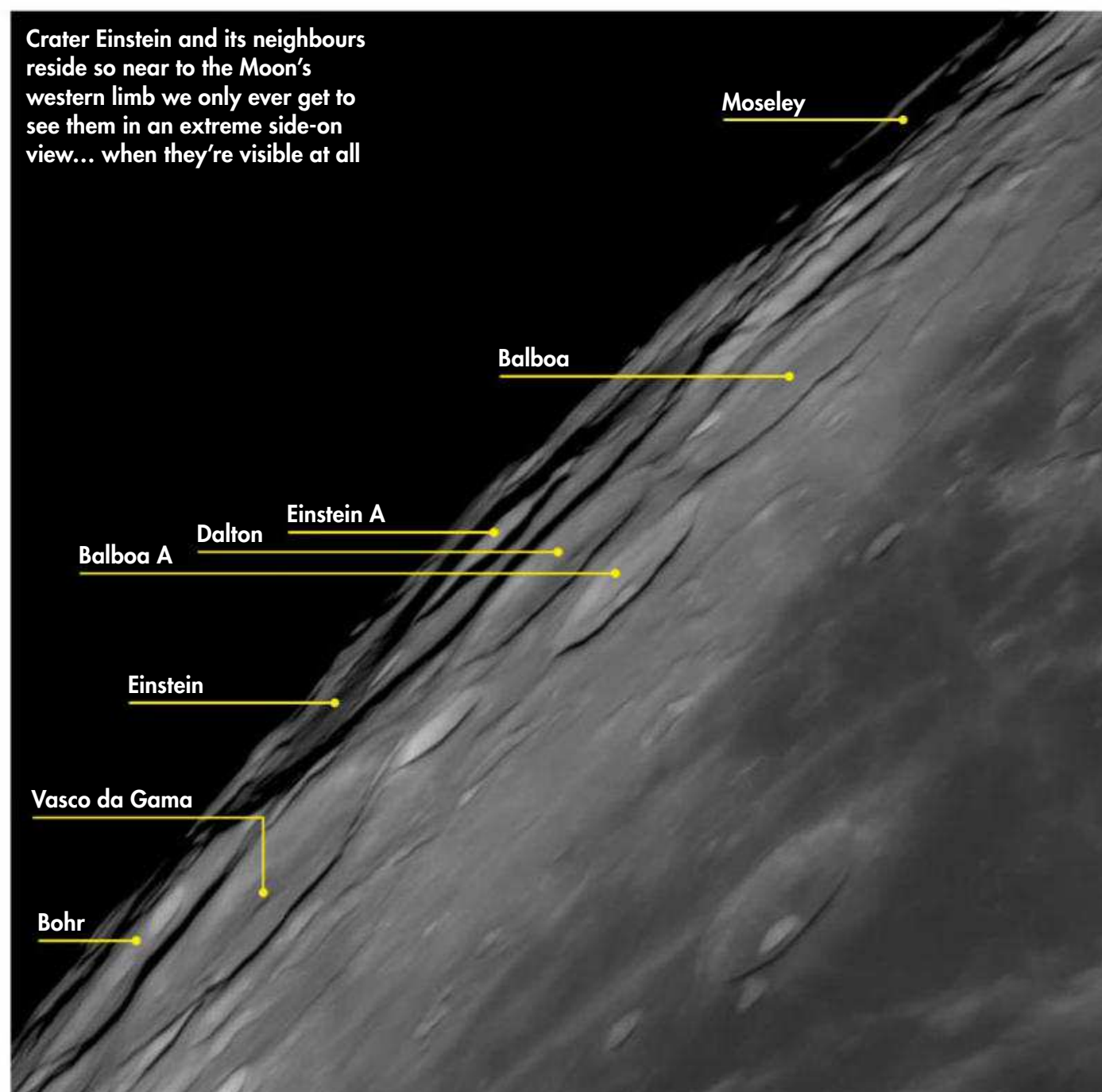
Our oblique view of Einstein should make identification of

surrounding features challenging but many of its neighbours are substantial in their own right. Touching Einstein's eastern rim is 61km **Dalton** with 47km **Balboa A** immediately to the east again. **Balboa** is the 70km crater located to the north of the midpoint between Dalton and Balboa A. South of Dalton sits the giant form of 94km **Vasco da Gama** with 70km **Bohr** nestled between its southwest rim and the south-southeast rim of Einstein.

Another challenge you might like to take on is trying to make out the irregular and very battered form of 90km **Moseley**, which is located immediately north of Einstein. With a lunar longitude of 90.2°, Moseley is even tougher to see than Einstein!

***“Libration rotates Einstein into view at certain times and out of view at others”***

Crater Einstein and its neighbours reside so near to the Moon's western limb we only ever get to see them in an extreme side-on view... when they're visible at all



# COMETS AND **ASTEROIDS**

43 Ariadne is well-placed in Pisces for observing from the UK throughout October

Asteroid 43 Ariadne reaches opposition on 13 October within the wedge formed by the stars representing the rope tying together the two fishes of Pisces. Ariadne's entire journey this month is contained within this wedge, meaning that the asteroid is well-placed for UK sighting in October.

At the start of the month Ariadne can be found approximately 4° east-southeast of mag. +3.6 Eta (η) Piscium. On 1 October the asteroid has a magnitude of +10.6. This slowly increases over the following days to reach a peak value of +10.3 by 13 October when Ariadne will have moved south and east to lie 5° north of mag. +4.3 Epsilon (ε) Piscium. By 31 October, it sits a little

over 3° north of mag. +4.4 Delta (δ) Piscium. At the end of the month it will have faded slightly to mag. +10.9.

Ariadne is a siliceous, or stony, type of asteroid (S-type) with a fairly high reflectivity, or albedo, of 27.4%. This means

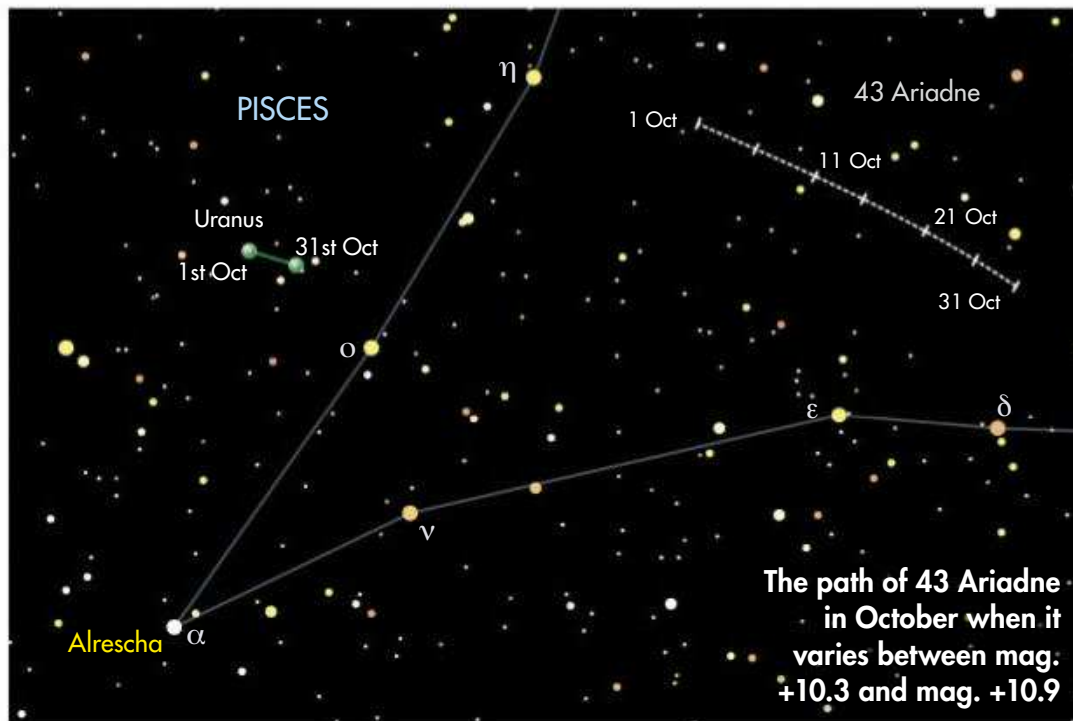
that 27.4% of incident sunlight is reflected back from its surface. It's unusual in that one of its dimensions is almost twice that of the others; its tri-axial size being 95x60x50km.

It's the second largest body in the Florian family, a large group

of siliceous asteroids in the inner main asteroid belt between the orbits of Mars and Jupiter. Around 4-5% of all main belt asteroids belong to the Florian family. Because of the group's poorly defined boundaries, and the extreme peripheral location of its largest asteroid, 8 Flora, this asteroid group has also sometimes been referred to the Ariadnean family.

Discovered on 15 April 1857 by English Astronomer NR Pogson,

Ariadne orbits the Sun once every 1,194.8 days (3.27 years) with an aphelion distance of 2.6AU and perihelion distance of 1.8AU. Its magnitude swings from a dim mag. +13.4 to mag. +8.8 at favourable oppositions.



## STAR OF THE MONTH

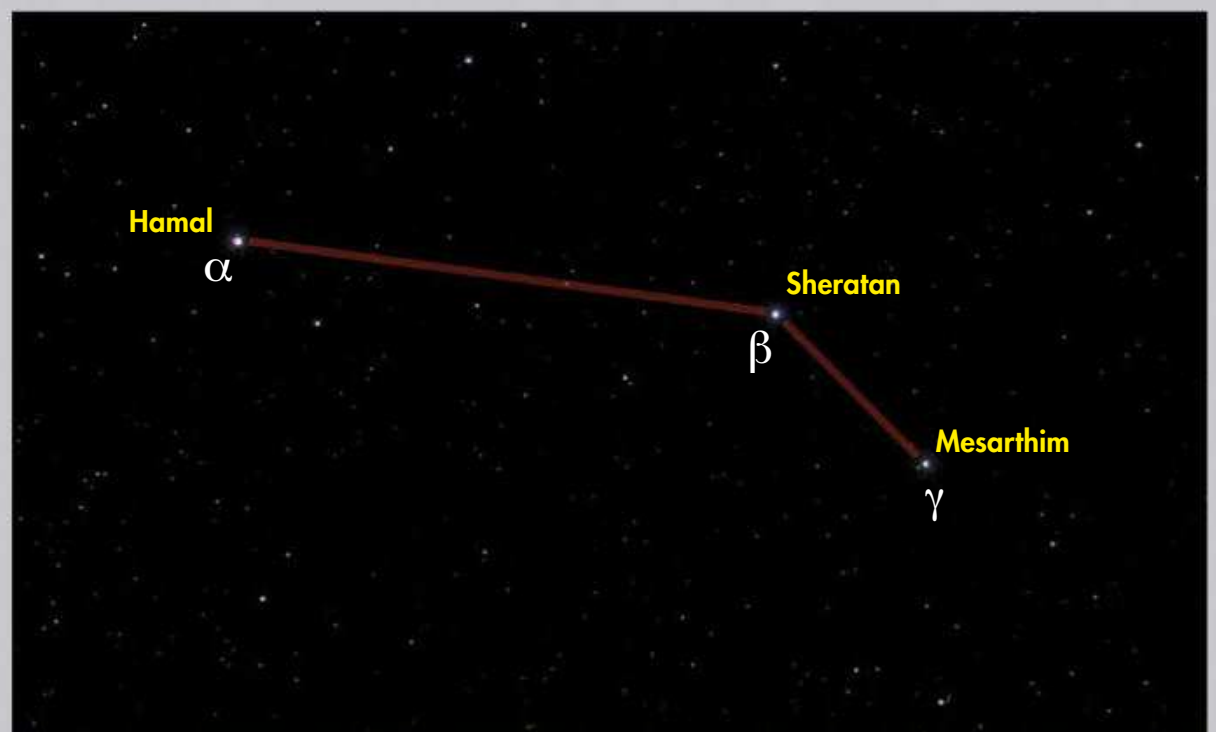
Hamal proves that being average can be interesting

Aries is often described as looking like a bent line. Although this does the much larger form of the celestial ram a great injustice, it does provide a convenient method of identifying Hamal (Alpha (α) Arietis), the star marking the eastern end of the 'bent line'.

Hamal is a bright star shining away at mag. +2.0. It lies at the relatively close distance of 65.8 lightyears from Earth and is believed to play host to a large orbiting planet, 1.8x more massive than Jupiter and orbiting its primary every 381 days.

The name Hamal means 'the lamb' and it's the brightest star in Aries. It's a cool orange giant, 14.9x larger than our Sun and 1.5x as massive. Its bolometric luminosity – that is its luminosity across all wavelengths – is 91x larger than the Sun's. Hamal has exhausted its core hydrogen and is now evolving along the path of becoming a red giant star.

This is one of the few stars that has had its diameter accurately measured. In this case, Hamal's disc subtends an angle of 0.00680



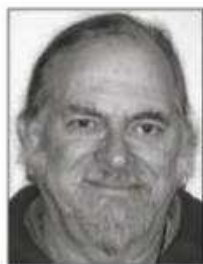
▲ Hamal shines at mag. +2.0, which also makes it the 50th brightest star in the entire night sky

arcseconds. This measurement also revealed the presence of limb darkening, a phenomenon that makes the limb regions of a star appear darker than those in the centre. This is a well-known effect that has been seen on our own Sun and results from looking into cooler layers of the star at the edges than when you're looking straight at its centre.

In this section we often reveal exciting facts about the stars being discussed that give them a hidden persona and make them stand out

against their neighbours. In the case of Hamal, the star is characterised by being utterly normal. Although this may sound a little dull, it's actually an important attribute because it provides a useful baseline against which you can compare other stars.

The only unusual thing about Hamal is that its metallicity is around half that of our Sun's. A star's metallicity describes the amount of elements it contains other than hydrogen or helium.

**STEPHEN TONKIN'S****BINOCULAR TOUR**

A hockey stick, an ice giant and tricky triple are waiting to be discovered round the Triangle

☑ Tick the box when you've seen each one

**1 M34**

**10x 50** Let's kick off with a cluster that's a delight in binoculars of any size. You will find M34 5° (about one field of view in 10x50s) from Algal (Beta (β) Persei) in the direction of star Almaak (Gamma (γ) Andromedae); you are looking for a fuzzy patch with a similar apparent size to the Moon. Your 10x50s should show 12 or more stars, the brightest of which form a wonky 'H'-shape. You are looking at starlight that left this 220 million year-old, 14 lightyear wide cluster about 1,400 years ago. ☐ **SEEN IT**

**2 NGC 752 AND 56 ANDROMEDAE**

**10x 50** Locate Beta (β) Trianguli and place it at the bottom of the field of view, and NGC 752 should appear near the top, just to the left of a close pair of 6th magnitude deep yellow stars (56 Andromedae). Rising from them is a 1.6° long chain of slightly fainter stars; together with

56 And, they make the Hockey Stick, with NGC 752 as a somewhat oversized ball. It's twice the diameter of M34 and you should be able to resolve several yellowish stars. Yellow stars are unusual for an open cluster. ☐ **SEEN IT**

**3 M33**

**10x 50** You're going to need a transparent sky and dark-adapted eyes for our next object, the galaxy M33, which is 4° from Metallah (Alpha (α) Trianguli) in the direction of Mirach (Beta (β) Andromedae). It is face-on to us and its light is spread out over an area of sky even larger than NGC 752, so all you will see is an ethereal glow. Although its magnitude is given as +5.5, this is an integrated magnitude and it has a very low surface brightness, making it difficult to distinguish if there is any skyglow. ☐ **SEEN IT**

**4 14 ARIETIS**

**15x 70** 2.5° north of Hamal (Alpha (α) Arietis), in the direction of Gamma (γ) Trianguli, lies the triple star, 14 Arietis. The brighter two members (magnitudes +5.0 and +8.0) are easy

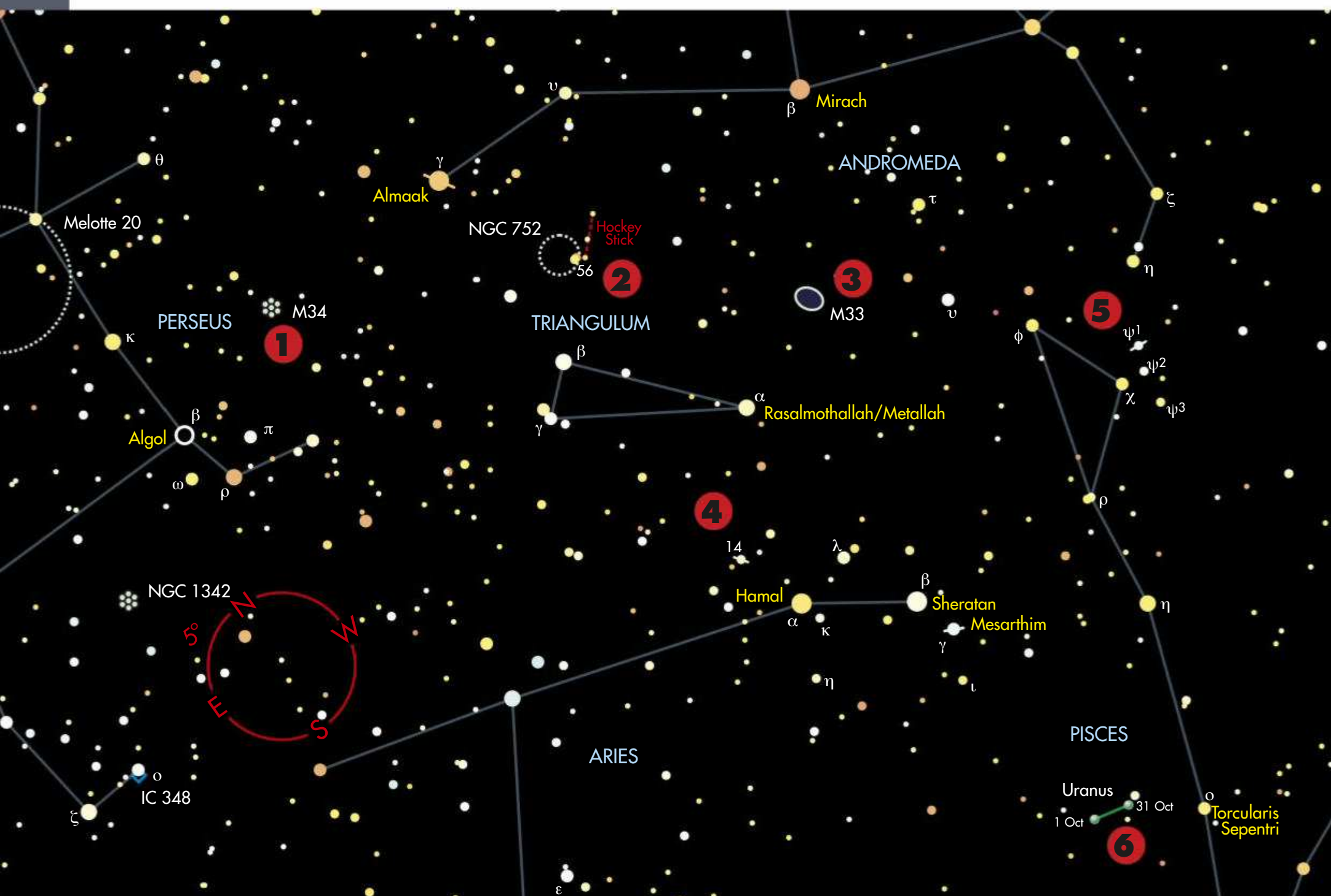
and separated by 108 arcseconds. The third is why we've switched to larger binoculars: it's easy to split – if you can see it. It is only mag. +10.9, so a real challenge for 15x70 binoculars, even on a very dark night. The primary star seems to be part of an astrometric binary system, meaning that it has a massive invisible companion, probably a neutron star, that it orbits. ☐ **SEEN IT**

**5 PSI<sup>1</sup> PISCUM**

**10x 50** Psi<sup>1</sup> (ψ<sup>1</sup>) Piscium is in the northern extreme of Pisces, 1.5° from Chi (χ) Piscium in the direction of Eta (η) Andromedae. It is a delightful double star with two brilliant white members of similar brightness (mag. +5.33 and mag. +5.55) separated by 30 arcseconds. It is a good test of your optics and the steadiness with which you hold the binoculars. If you find it difficult to split, make sure that your focus is perfect and try mounting the binoculars. ☐ **SEEN IT**

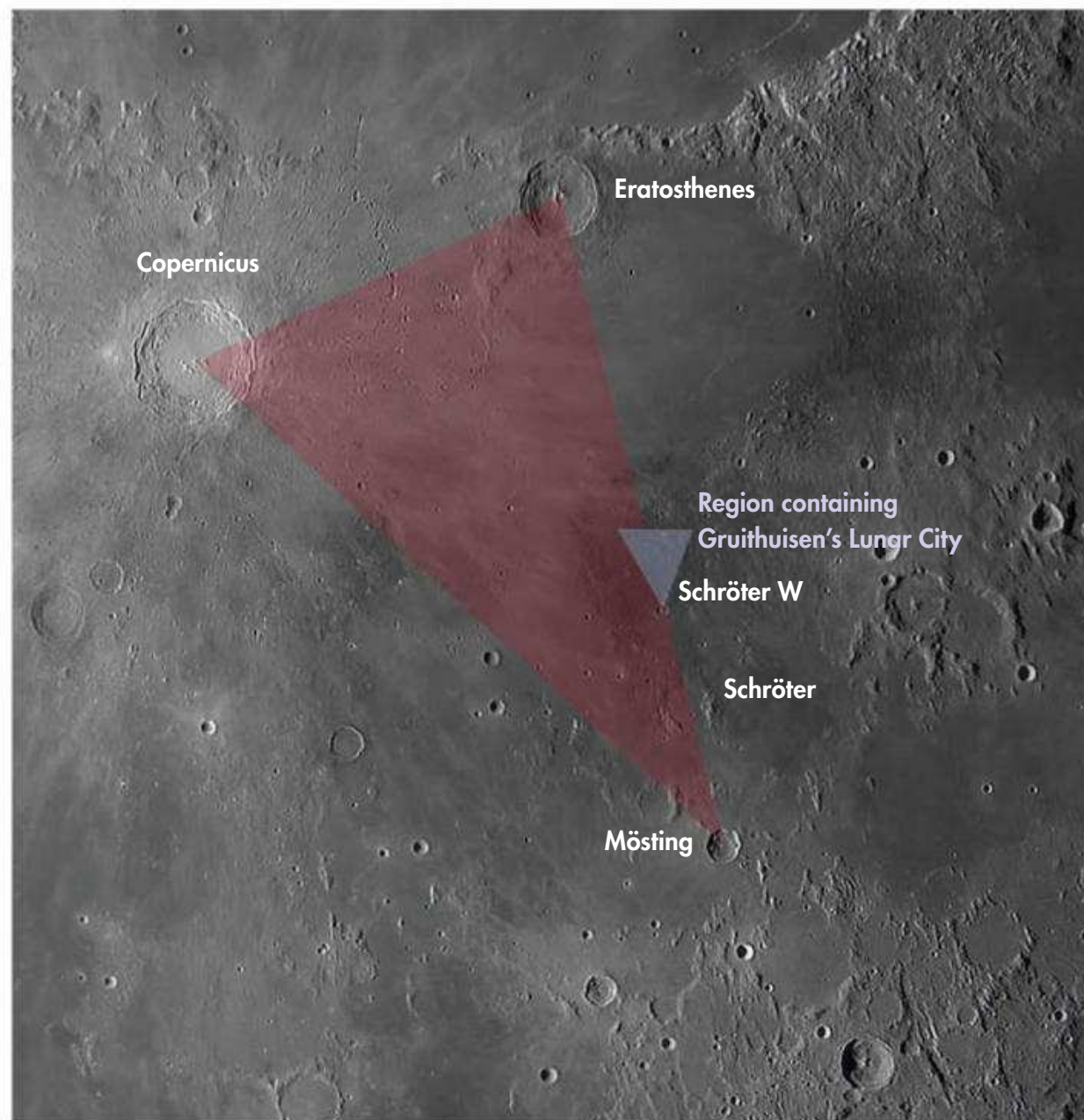
**6 URANUS**

**10x 50** At mag. +5.7 Uranus is nominally a naked-eye object, but in practice in Britain, that's rare. However, even small binoculars make the planet spottable. Identify Omicron (ο) Piscium and pan about 3.5° east-northeast where Uranus is easily the brightest object in the area. During October it moves 1.25° westward. To be sure of your identification, observe it on several nights and sketch its position in relation to other stars: if it moves, it's Uranus. ☐ **SEEN IT**



# THE SKY GUIDE CHALLENGE

How and when to spot an ephemeral lighting effect that appears to create a lunar city



***“A lighting effect makes a small section of the Moon appear to have streets”***

Atlas ([www.ap-i.net/avl/en/start](http://www.ap-i.net/avl/en/start)) provide co-longitude information. This month, co-longitude 185° occurs in the early afternoon on 2 October when the Moon is, annoyingly, below the UK's horizon. It next occurs on 1 November, just after 02:00 UT.

It's not a real city of course, but a lighting effect that makes a small section of the Moon appear to have linear 'streets' in a leaf-like pattern. To locate it, first find the giant craters Copernicus (93km) and Eratosthenes (59km). Imagine them forming one side of a large isosceles triangle. The other vertex lies further south, close to the morning terminator, marked by the much smaller crater Mösting (26km).

From Mösting, head back along the line towards Eratosthenes. About one fifth of the way you'll find the heavily eroded Schröter (35km). Keep going towards Eratosthenes and the next small but identifiable crater is Schröter W (10km), which has a smaller crater, Schröter A (3km), inside it. The 'streets' of Gruithuisen's city appear to radiate north from Schröter W.

The feature is named after Franz von Paula Gruithuisen who, from a time when it was believed the Moon was populated, made multiple observations of the 'city'. He called it Wallwerk and was met with significant scepticism when he published his discovery of the city's streets and buildings in 1824.

▲ In 1824 Franz von Paula Gruithuisen thought he had spotted evidence of a lunar civilisation

This month's challenge is to track down and observe the clair-obscur feature known as Gruithuisen's Lunar City. Despite its rather grandiose name, it's actually quite tricky to find, not helped by the fact that it vanishes fast as the Sun sets on its 'streets'.

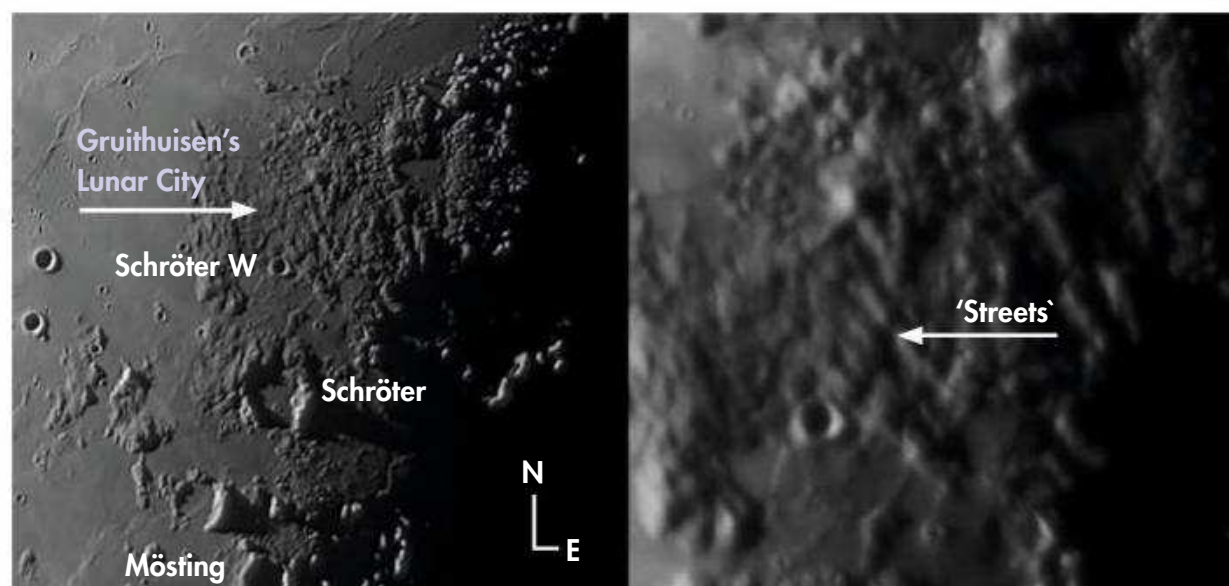
A clair-obscur effect is a trick of the light that results in shadows appearing to create recognisable objects. They add an extra challenge to lunar observation as they only appear at certain times, when sunlight hits the Moon's surface at the correct angle. The best-known are the Lunar X and Lunar V.

The time a clair-obscur effect will appear is given by the position of the Moon's terminator rather than regular clock time; the Moon's libration interferes with that. Consequently, clair-obscur effects are often described in terms of the Moon's co-longitude, a figure identifying the location of the morning terminator on the lunar surface. The morning terminator is the one that leaves light in its wake as it sweeps across the Moon's disc; the one that brings darkness is the evening terminator.

At first quarter the co-longitude is close to 0°; at full it's near 90°; at last quarter

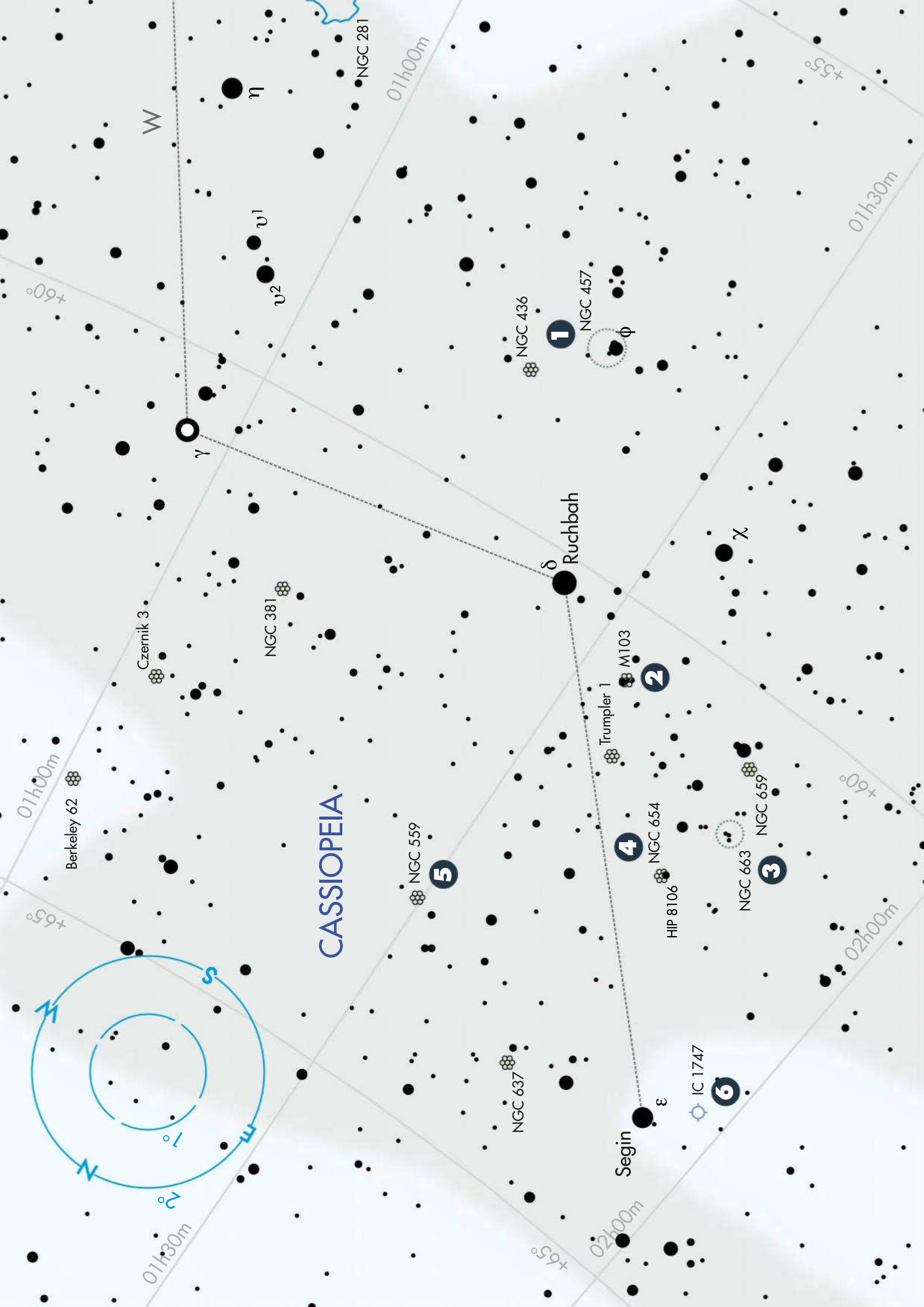
(when the morning terminator is halfway across the far side of the Moon) it's around 180°; and at new Moon it's about 270°. Co-longitude cannot be precisely tied to a particular phase because of the distorting effects of libration. Gruithuisen's Lunar City is visible approximately one day after last quarter, more specifically at lunar co-longitude 185°.

Freeware apps such as WinJUPOS ([jupos.org/gh/download.htm](http://jupos.org/gh/download.htm)) and Virtual Moon



▲ (Left) The city's location and (right) the linear features that were thought to represent streets

PETE LAWRENCE X 3



# DEEP-SKY TOUR


From a pair of glowing eyes to a planetary nebula with a surprise at its centre

☑ Tick the box when you've seen each one

## 1 NGC 457

 At mag. +6.5, NGC 457 isn't a tricky object to find. It's located adjacent to mag. +4.9 Phi (φ) Cassiopeiae and this star, together with mag. +7.0 HIP 6229 located 2 arcminutes to the southeast, create the impression of two eyes staring back at you. The cluster stars form a 'body' with outstretched 'arms'. Unsurprisingly it is known by various unofficial nicknames including the Owl, E.T. and Dragonfly (where the arms become wings) Cluster. NGC 457 is 7,900 lightyears distant, the two bright stars being foreground objects. There are around 150 stars down to mag. +15, around 45 of which can be seen through a 6-inch scope, a figure that more than doubles through an 8-inch instrument. ☐ SEEN IT

## 2 M103


 Our next target is another cluster located 1° west-northwest of mag. +2.7 Ruchbah (Delta (δ) Cassiopeiae), forming an

isosceles triangle with Ruchbah and mag. +4.7 Chi (χ) Cassiopeiae. Messier 103 is a mag. +7.4 open cluster with a rather loose appearance through the eyepiece. In fact, for a long while this cluster appeared so loose that astronomers weren't certain whether it was a *bona fide* cluster at all. It is now known that at least 40 of its members share the same proper motion, so they are indeed related. The non-associated double star Struve 131 slightly overpowers the cluster, appearing as a mag. +7.3 primary separated from a mag. +9.9 secondary by 14 arcseconds. ☐ SEEN IT

## 3 NGC 663

 To find the next item on this month's tour – the large, mag. +7.1 open cluster NGC 663 – imagine the mid-point between Ruchbah and mag. +3.3 Segin (Epsilon (ε) Cassiopeiae). Head southeast from this location for 1° and you'll arrive at NGC 663. A 6-inch scope will show around 30 stars in an area roughly 0.25° across. There appear to be a number of slightly brighter stars ring-fencing the fainter members of the cluster. Overall there also appears to be a slight concentration of stars towards the cluster's core. A 10-inch scope will double the number of cluster members visible through the eyepiece to around 60 in total. ☐ SEEN IT

## 4 NGC 654

 Our next stop is open cluster NGC 654. You'll find this one 0.5° southeast of the line between Ruchbah and Segin, slightly displaced towards Segin. A bright star appears embedded within it, but unlike NGC 457, in this case the mag. +7.3,



### THIS DEEP-SKY TOUR HAS BEEN AUTOMATED

ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.




yellow supergiant HIP 8106 may well be part of the cluster. This is a small grouping of stars that looks like a fuzzy patch through smaller instruments. It appears around 3 arcminutes across with 20 members through a 10-inch scope. NGC 654 is young, estimated to be around 15 million years of age, although there is some uncertainty about the precision of this figure. It's located 7,830 lightyears from the Sun. ☐ SEEN IT

## 5 NGC 559

  Our penultimate target lies 1.7° northwest of the mid-point of the line between Ruchbah and Segin. NGC 559 is a richly populated open cluster containing an estimated 120 stars. As ever, telescopes of different sizes will reveal different levels of detail with a 10-inch scope revealing around 20 members contained in an area that's approximately 3 arcminutes across. NGC 559 is quite irregular in shape with a number of brighter stars around its periphery and three notable stars forming a right-angled triangle within the core region. A 12-inch scope shows around one third of the total cluster population. Estimated to be around two billion years old, the cluster is listed at mag. +9.5, lies 3,700 lightyears away and has a spatial diameter of seven lightyears. ☐ SEEN IT

## 6 IC 1747

 Our final target for this month presents quite a challenge. Planetary nebula IC 1747 has a listed magnitude of +13.6 with a mag. +15.4 central star. It lies 0.5° southeast of Segin and with an apparent diameter of 26 arcseconds, so it is small and easy to mistake for a star. Start hunting using a low magnification and when you think you've found it, pile on the power. A 12-inch scope is recommended. At around 100x power the 'star' appearance gives way to a fuzzier look. However, it's when you're over 400x magnification that the odd appearance of IC 1747 becomes apparent. In its centre is a rather striking small dark circular hole. Although a ring shape is not an uncommon occurrence in planetary nebulas, it is the relatively small size of the dark hole at the centre of IC 1747 which makes it striking – almost as if it's been created by a cosmic-scale hole punch. ☐ SEEN IT

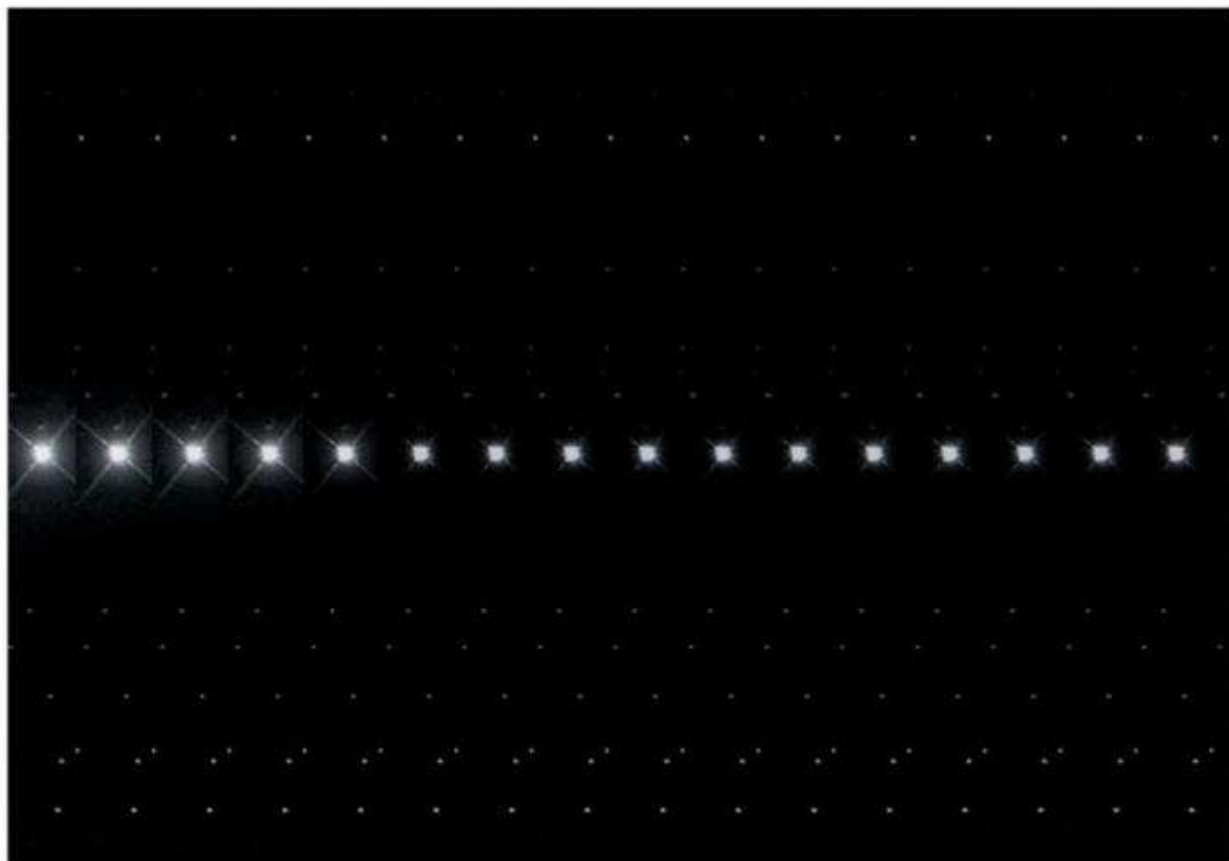
◀ NGC 457 has many names – the Dragonfly Nebula, the Owl Nebula and others – but its two brightest stars always seem to represent eyes

### YOUR BONUS CONTENT

Print out this chart and take an automated Go-To tour



# ASTROPHOTOGRAPHY



▲ A series of shots taken at regular intervals reveals Algol's change in brightness over an eclipse

## Revealing Algol's variability

### RECOMMENDED EQUIPMENT

A camera with telephoto lens or mounted on a telescope

### THE BIG PICTURE

#### THE KEY TO SUCCESS IS CALIBRATION USING FAINT THRESHOLD STARS

Algol is a bright variable star which is well placed for viewing in the UK. Its regular dips in brightness make it a fascinating astrophotographic subject but the big challenge is how to capture them effectively. Variations in sky transparency create issues with calibration so here we look at a simple way to achieve a rough

image calibration sufficient to show just how much Algol's brightness changes over its short, but regular period of variability. The main thrust of this method is to identify several faint threshold stars. If you can record them correctly, then the brightness of Algol can be confidently compared from one shot to another.

Algol (Beta ( $\beta$ ) Persei) is an eclipsing binary star in the constellation of Perseus. In Greek mythology, Perseus cut off the head of Medusa, a Gorgon who, if you looked into her eyes, would turn you to stone. He later used the severed head's still-functioning power to defeat the sea monster Cetus, so that he could rescue the princess Andromeda. Algol – which is also sometimes referred to as the 'Winking Demon' – supposedly represents one of Medusa's eyes, but instead of turning you to stone, it presents a wonderful opportunity to see a variable star in action.

Algol is actually a triple system made up from Beta Persei Aa1, Aa2 and Ab. The

variations in perceived brightness occur when the hot, bright primary Aa1 is covered by the larger but cooler secondary, Aa2. From Earth, the line of sight is such that both stars appear to pass in front of one another at regular intervals. When Aa2 passes in front of Aa1 a dip of 1.3 magnitudes is observed. When Aa1 passes in front of Aa2, the dip is so small that it can only be detected using specialist photoelectric equipment.

Aa1 and Aa2 are 0.062AU or 9.3 million km apart while the third component Ab orbits 2.69AU away from the main pair. The orbital period of Ab and the eclipsing pair is 681 days but Ab doesn't contribute

any brightness variations to the system as we see it from Earth.

The large dips occur at regular intervals of 2d 20h 48.9m but not being an integral number of days, the visibility of a dip requires it to occur at the right time – ie, when it's dark! During October and November optimally occurring dips occur on 20 October at 04:00 BST (03:00 UT), 23 October at 00:48 BST (22 October 23:48 UT), 12 November at 01:30 UT and 14 November at 22:18 UT. The eclipse dip sequence lasts for 9.6 hours.

Recording a dip with a camera is relatively easy to do but care needs to be taken to ensure that you don't bias the results in any way by adjusting the camera settings between shots. Similarly care should be exercised to avoid sky conditions that may create variations which are not linked to the true changes in brightness of the star.

The simplest way to show Algol's variation in brightness is to create a strip image by taking shots at regular intervals and then arranging them next to one another (as in the main image on this page). If you do this over the entire course of an eclipse dip the images should demonstrate the changes in brightness very effectively.

Another less work intensive method is simply to show the whole constellation of Perseus as a before-and-during shot. Before would be timed to record the whole constellation when Algol was at maximum brightness. During would show the whole constellation when Algol was in the middle of an eclipse. Placing both images together would then show just how dramatic the variation is.

The techniques introduced here can be re-employed for other eclipsing binary systems and it may be an interesting exercise to create a gallery, or album, revealing how each one varies compared to the others.

However you decide to do it, revealing variability in stars is a fundamental part of astronomy that has allowed us to decode many of the mysteries of the heavens. If you've never witnessed the variation of Algol before, attempting to photograph it will be something of a revelation. Good luck!

✉ Send your images to:  
[hotshots@skyatnightmagazine.com](mailto:hotshots@skyatnightmagazine.com)

# STEP BY STEP



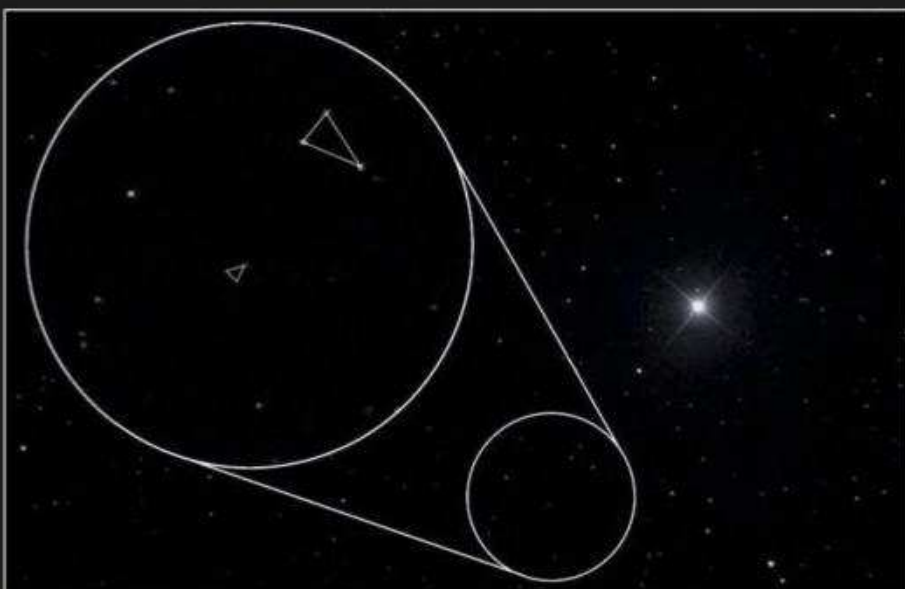
## STEP 1

Decide on how you want to present your results. For a strip showing several shots of Algol side-by-side, a larger image scale works best. This can be achieved using a telephoto lens or a camera attached to a telescope. For a before-and-during eclipse comparison pair covering the whole of Perseus (35x30°), a 28mm lens or shorter is ideal.



## STEP 3

Set your equipment up and frame either Perseus or Algol as required. Camera settings will depend on your particular setup but the aim here is not to produce a grossly too over-exposed shot of the star. Start with a value of ISO 400, a camera lens at f/8 (this will be fixed for a telescope of course) and an exposure of, say, 4s.



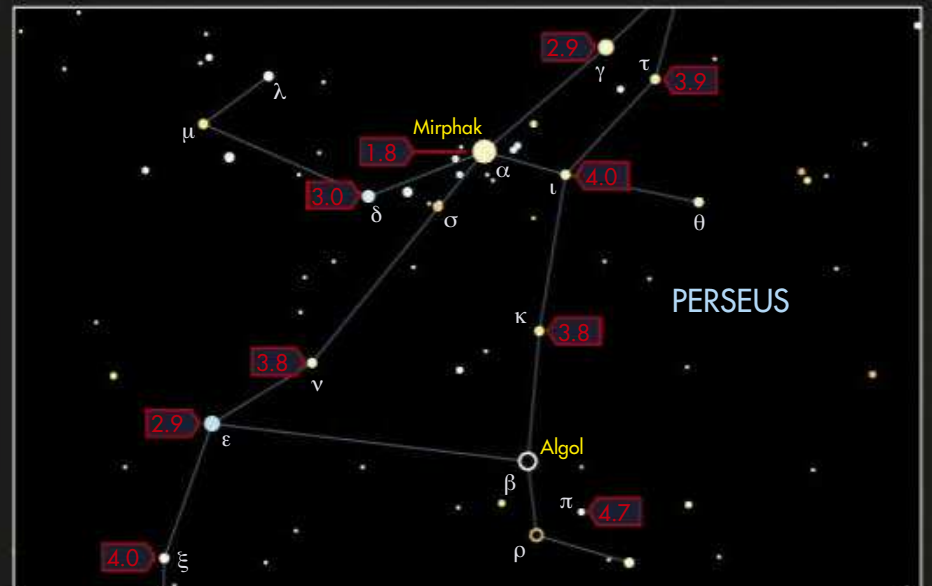
## STEP 5

Take shots at intervals of say, every 15 or 30 minutes, covering the start or end of an eclipse. Catching a full 9.6 hour cycle is difficult and requires luck with the timing of the eclipse's start. Check each shot to ensure the threshold stars remain visible. If they disappear, increase camera sensitivity; if too prominent, knock sensitivity back slightly.



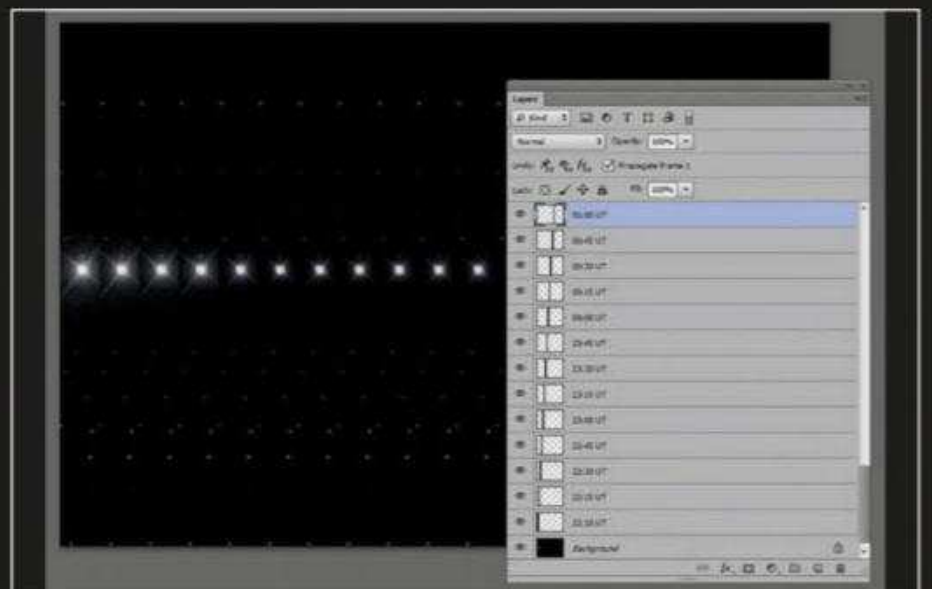
## STEP 2

A tracking mount is recommended for sharp star images but relaxing this requirement allows the use of fixed platforms such as a tripod. Here, the best option is to let the stars trail for, say, five minutes. The star trails can then be compared side-by-side. A fixed platform will need to be re-pointed at frequent intervals to keep Algol in view.



## STEP 4

The shot should ideally contain stars as dim as the faintest comparison star shown here. Adjust your camera settings so that the faintest star marked shows up in the image. For wide shots there are many choices, but for the narrow image make sure that Pi ( $\pi$ ) Persei is showing. Note any star patterns on the threshold of visibility in your shot.



## STEP 6

When you're done, download your images onto a computer and, using a layer-based editor, align Algol across the layers. Make a vertically tall but horizontally narrow selection strip centred on Algol, copy the star from each layer and paste into a new image next to one another. The final sequence should show the dip into, or rise from, eclipse.

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Your photographs and notes  
could help reveal more  
about the aurora (top) and  
noctilucent clouds (bottom)



# IMAGING FOR SCIENCE

## Part 6: Atmospherics

Our guide to building scientific value into your astrophotos returns. This month we cover phenomena on the boundary of meteorology and astronomy such as the aurora and noctilucent clouds

PETE LAWRENCE X 2



Atmospheric phenomena sit on the boundary between meteorology and astronomy. Though some effects, such as ice halos and rainbows, are obviously more a part of Earth's climate, observing them still contributes to the study of how our planet's atmosphere interacts with sunlight and space weather.

Phenomena such as noctilucent clouds (NLCs) and the aurora definitely sit in the domain of astronomy. In order to be useful to science, images of targets like these should be annotated with the same extra information that would be added to any other type of astronomical observations. This includes the date and time images were taken and the location they were taken from. In this feature, we'll look at a few more specific requirements to add to your images of both NLCs and auroral displays to make them scientifically relevant.

As well as the long term usefulness of such records, now that social media can spread information rapidly, informing others of potential displays with clarity and accuracy will greatly enhance the chances of it being seen from other locations too.

## Hardware & software

### HARDWARE

- ▶ A camera with manual control that can take long exposures, such as a DSLR
- ▶ A tripod or tracking mount
- ▶ A remote shutter release, preferably programmable for time-lapse sequences

### SOFTWARE

- ▶ An image viewer that can read EXIF headers, such as FastStone Image Viewer ([www.faststone.org/FSViewerDetail.htm](http://www.faststone.org/FSViewerDetail.htm))
- ▶ A graphics editor for image annotation, such as GIMP ([www.gimp.org](http://www.gimp.org))
- ▶ Planetarium software to work out star altitudes, such as SkyChart ([www.ap-i.net/skychart/en/start](http://www.ap-i.net/skychart/en/start))



#### ABOUT THE WRITER

*Sky at Night* presenter Pete Lawrence is an astronomer and astrophotographer who holds a particular interest in digital imaging

ISTOCK, PETE LAWRENCE X 3

## Submit your pictures for science



"The Aurora and Noctilucent Cloud Section of the British Astronomical Association encourages observations of both the aurora and NLCs; the recruitment and training of observers; and the collection, analysis and reporting of these events in the northern hemisphere," says section director Sandra Brantingham (pictured).

"The present observer network comprises members of the BAA or other astronomical societies, individual observers, professional meteorologists and officers at sea and in the air. Observations are collected mainly from the British Isles and other European countries, with a few reports being received from Canada and the United States.

"Our section investigates the behaviour of the mid-latitude storm aurora as the polar auroral oval expands during active conditions, as well as the fluctuations of NLCs between May and August. The original reports received from observers are placed in the archives of the University of Aberdeen and the details are the subject of occasional newsletters, reports and technical papers published in the BAA Journal.

"Recently a new atmospheric phenomenon called STEVE (Sudden Thermal Emission Velocity Enhancement) has been seen by observers to the west of main aurora displays. Therefore it can be seen much further south than a main display and may be seen on its own.

"NLC formations this year have been massive and have been seen as far south as southern France, but they are only visible between 22:00 UT and 02:00 UT."

To contribute to the Section, send any reports and photographs to [sandra-b@hotmail.co.uk](mailto:sandra-b@hotmail.co.uk)

These would probably rate a five on the NLC scale (see page 71)

# PROJECT 1

## The imaging basics: GENERAL RECORDING

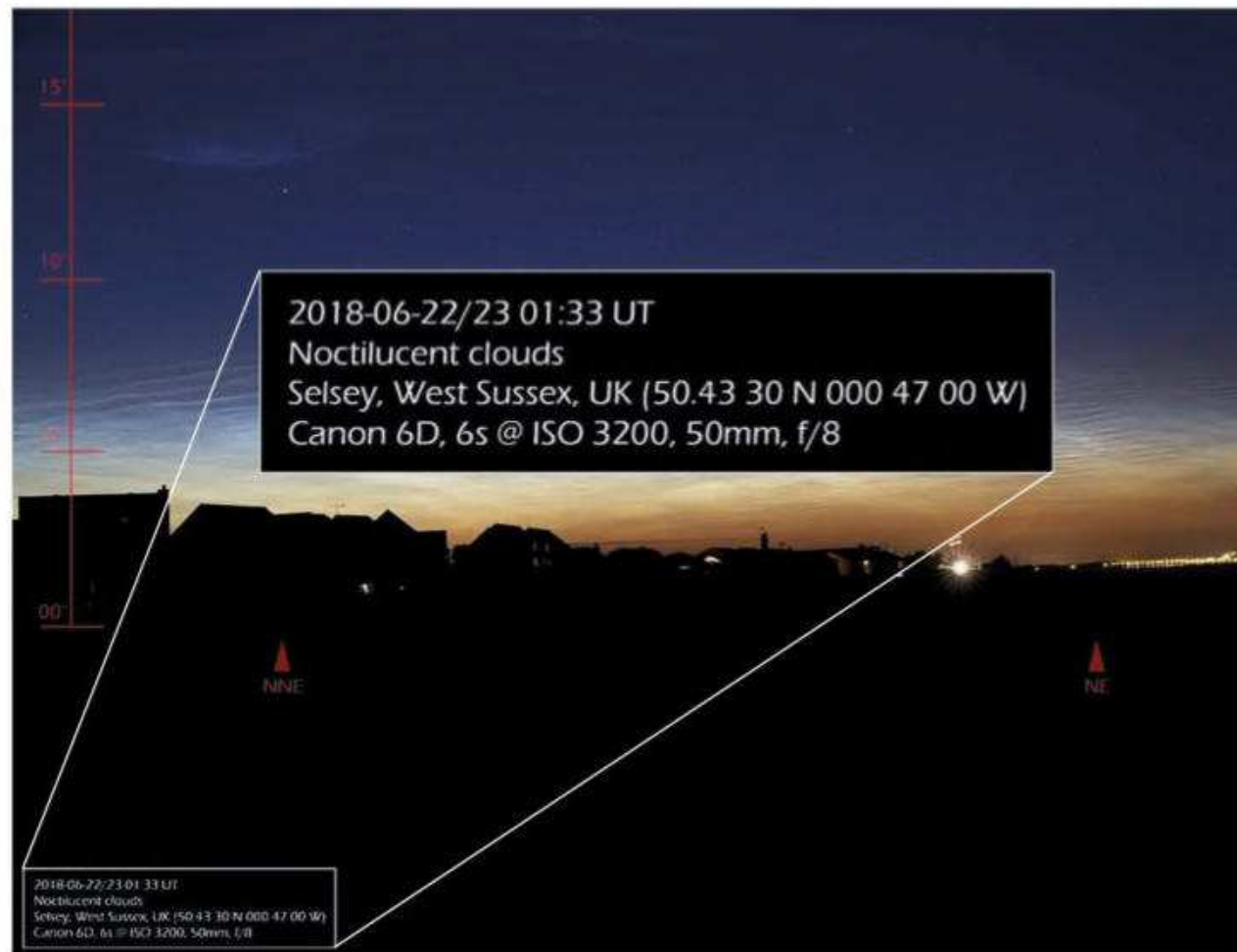
### More information will give your images more scientific value

Annotating your image in a layer-based editor ensures the salient details are recorded and displayed for all to see. Include the date, time (UT) and location, preferably with additional information about equipment and exposure.

Imaging auroral or noctilucent cloud displays requires similar disciplines. These phenomena are best suited for wide- or mid-field lenses attached to a DSLR mounted on a tripod. Telephoto zoom lenses can also be used to focus in on fine detail during bright displays. More detailed time-lapse images are very useful for determining exactly how structures change with time. If you record a time-lapse sequence, make sure to add the start time, frame interval and end time on it.

At a bare minimum, it's essential to note the location, date and time on your images to add value to them, and your camera's date and time should be set against the most accurate source possible. Dates should be recorded ideally as a double date: for example June 12/13 would refer to the evening of 12 June into the morning of 13 June. The time you took the photo should be recorded to the nearest minute and noted in UT. Locations can be identified by latitude and longitude, which you can find online from resources such as Google Earth or a good old paper map. Alternatively, the name of the nearest town or city is better than nothing.

It is useful to attempt to image at least two background stars at the same time as a display. For example, during NLC season in the UK, the bright star Capella (Alpha ( $\alpha$ ) Aurigae) is often conveniently placed behind displays along with the



dimmer, medium bright stars that form Auriga. If these are recorded in a photo, the altitude and azimuth of display features can be determined.

Camera exposures don't always record the brightness of features as they would have appeared to the naked eye, so it's useful to include a physical report of the brightness you actually saw.

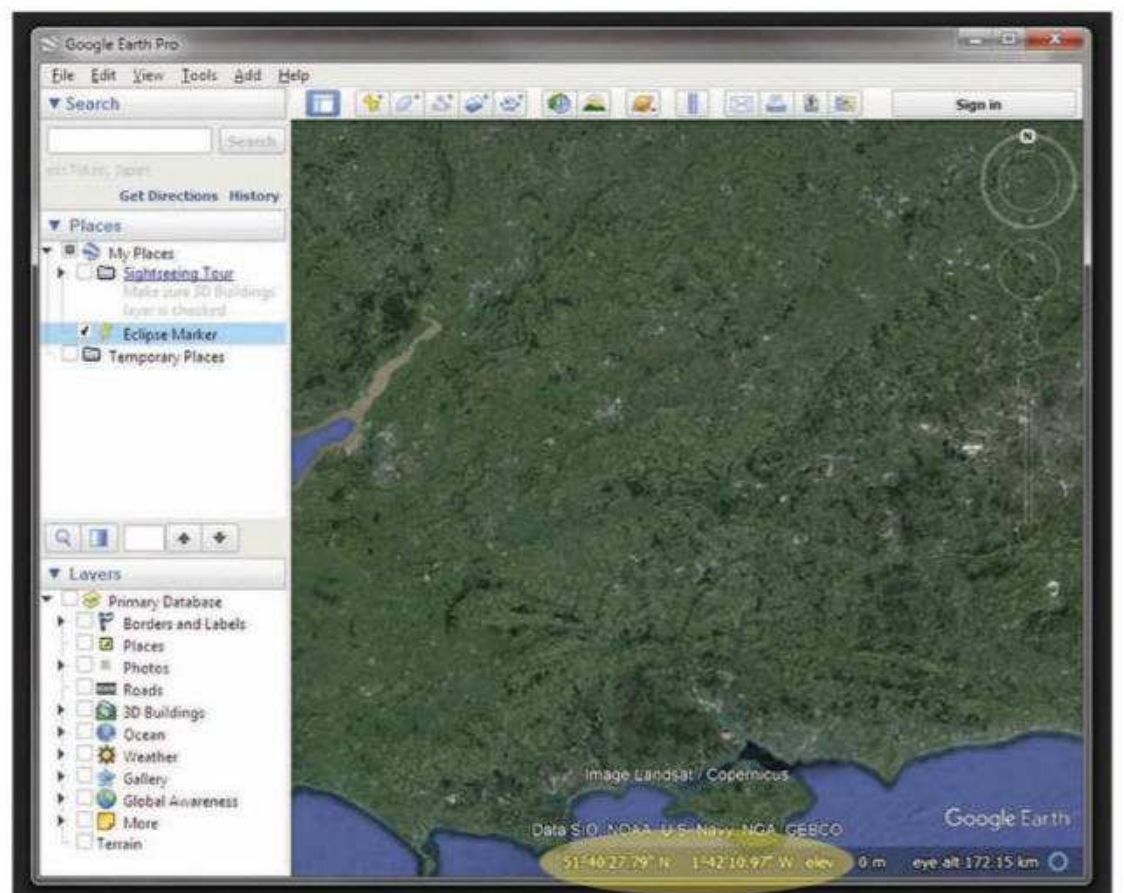
As always, write all the details directly onto photographs using a graphics editing program like GIMP. Annotating images in this way ensures that all the relevant information stays with the image and is immediately available to future viewers. ►

▲ Annotate your image in a layer-based editor to record the date, time (UT) and location it was taken. Additional information can include equipment and exposure information

▼ Latitude and longitude values can be determined from resources such as Google Earth



▲ Set your camera's date and time from an accurate source, preferably before each imaging session



## PROJECT 2

**GLOW (N)**

Similar to northern twilight;  
A faint glow may be an indication  
of impending auroral activity

**VEIL (V)**

Often appears as a  
background sheet of  
auroral light covering  
large areas of sky during  
bright and active displays

**RAYED ARC (RA)**

Auroral arc with vertical columns of light.  
Folds or kinks may appear forming a  
Rayed Band (RB). Isolated Auroral Rays  
(RR) may sometimes be seen

**PATCHES (P)**

Isolated patches of auroral light.  
May appear as Homogenous  
Patches (HP) or Rayed Patches (RP)

**HOMOGENOUS ARC (HA)**

An arc of uniform auroral light.  
Where the arc forms twists or  
kinks it becomes known as a  
Homogenous Band (HB)

**CORONA (C)**

Should auroral activity extend further south  
during a particularly active display, an  
auroral corona may appear overhead

# Imaging the AURORA

## The altitude, latitude and intensity of a sightings are all of interest

The aurora is a popular photographic target. Its ephemeral light, combined with the sense of awe you can't help feeling when you're standing beneath a display, creates a combination that is hard to resist. Science can be done with regular cameras as long as each image carries with it at least the date, time and location information.

On average, auroral activity tends to occur in a ring around each magnetic pole, which is known as an auroral oval. The closest the northern hemisphere's auroral oval comes to the UK is above northern Norway and Iceland.

In times of weak activity the oval may shrink back towards the magnetic pole, while in periods of enhanced activity it can expand in size, becoming visible across the whole of the UK. The probability of seeing the aurora increases as you get closer to the oval, so in the UK this means that the north has a greater chance than the south.

With any auroral sightings, the extent, structure and how visible they are at various latitudes are of particular scientific interest, and records of displays that happen away from the regular oval viewing locations are very valuable. You can estimate the

altitude of aurora features in your photographs by capturing a reference star in the image.

Recordings of the phenomenon known as 'STEVE' (Sudden Thermal Emissions Velocity Enhancement) are currently of particular interest. STEVE is a recently recognised feature that was thought to be associated with some auroral displays. It typically appears as a narrow pinkish band visible south of a main display. The mechanisms that produce STEVEs are different from those that cause a regular aurora display.

Typically seen to the west from northern Scotland or slightly more towards the northwest as you head further south, STEVE is a short-lived phenomenon, easily missed as it appears detached from a main display. STEVE displays last about an hour before fading, so vigilant observations in the right direction at least every 15 minutes are needed to catch them.

### ▲ Common auroral structural forms

▼ The phenomenon called  
STEVE, photographed  
from an aircraft window,  
with the Zodiacal Light to  
the right of it



▲ Aurora in West Sussex, June 2018. The rarity of sightings this far south makes them especially important to record



## PROJECT 3

Imaging  
NOCTILUCENT  
CLOUDS

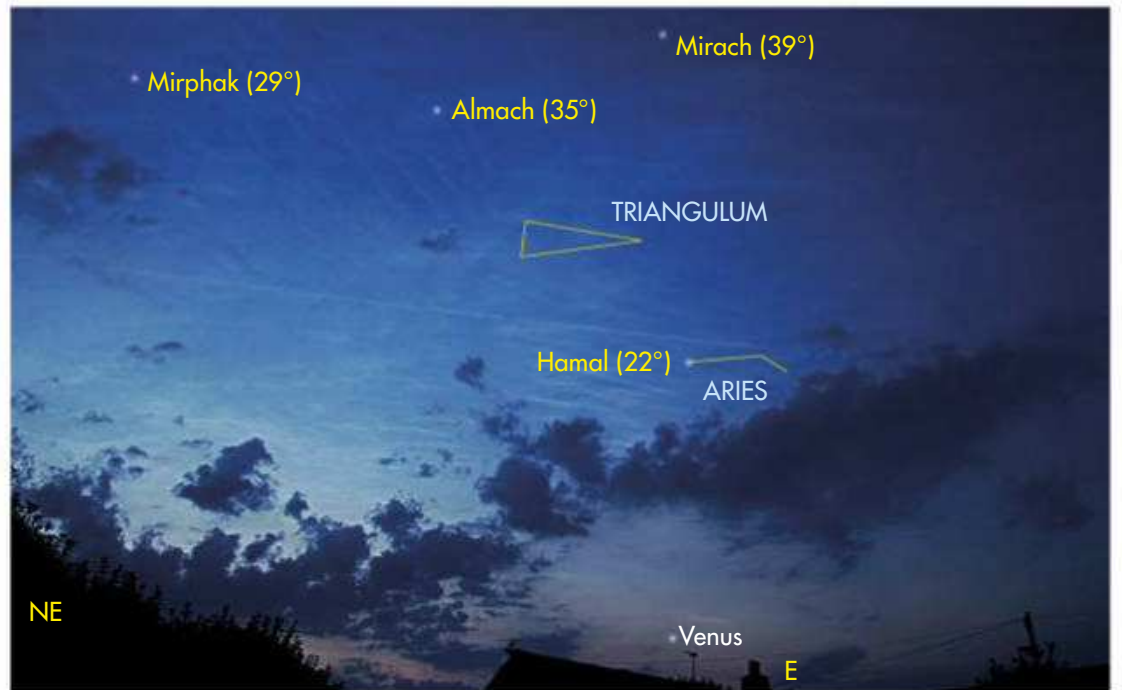
**There's a lot to be learnt about this eerily illuminated nocturnal event**

Noctilucent clouds are high-altitude ice clouds that form 82km up in the mesosphere, lit up by the pre-dawn or post-sunset Sun to create ethereal displays that take many shapes and forms. The nature of NLCs is slowly being unravelled through observational recording, much of it carried out by amateur astronomers, though the frequency and brilliance of displays is difficult to predict.


One particularly useful area of study involves creating time-lapse sequences to reveal how the clouds flow and evolve with time. These time-lapses can be wide-field or magnified sequences concentrating on small, structured areas.

It's useful to make a note of the structures in NLCs, as well as display brightness, which is typically done using a five-point scale:

- 1** Very weak, barely visible to the naked eye
- 2** Clearly visible but of low brightness
- 3** Clearly visible, standing out sharply against the background sky
- 4** Very bright and obvious even to casual observers
- 5** Extremely bright and able to illuminate objects facing the display

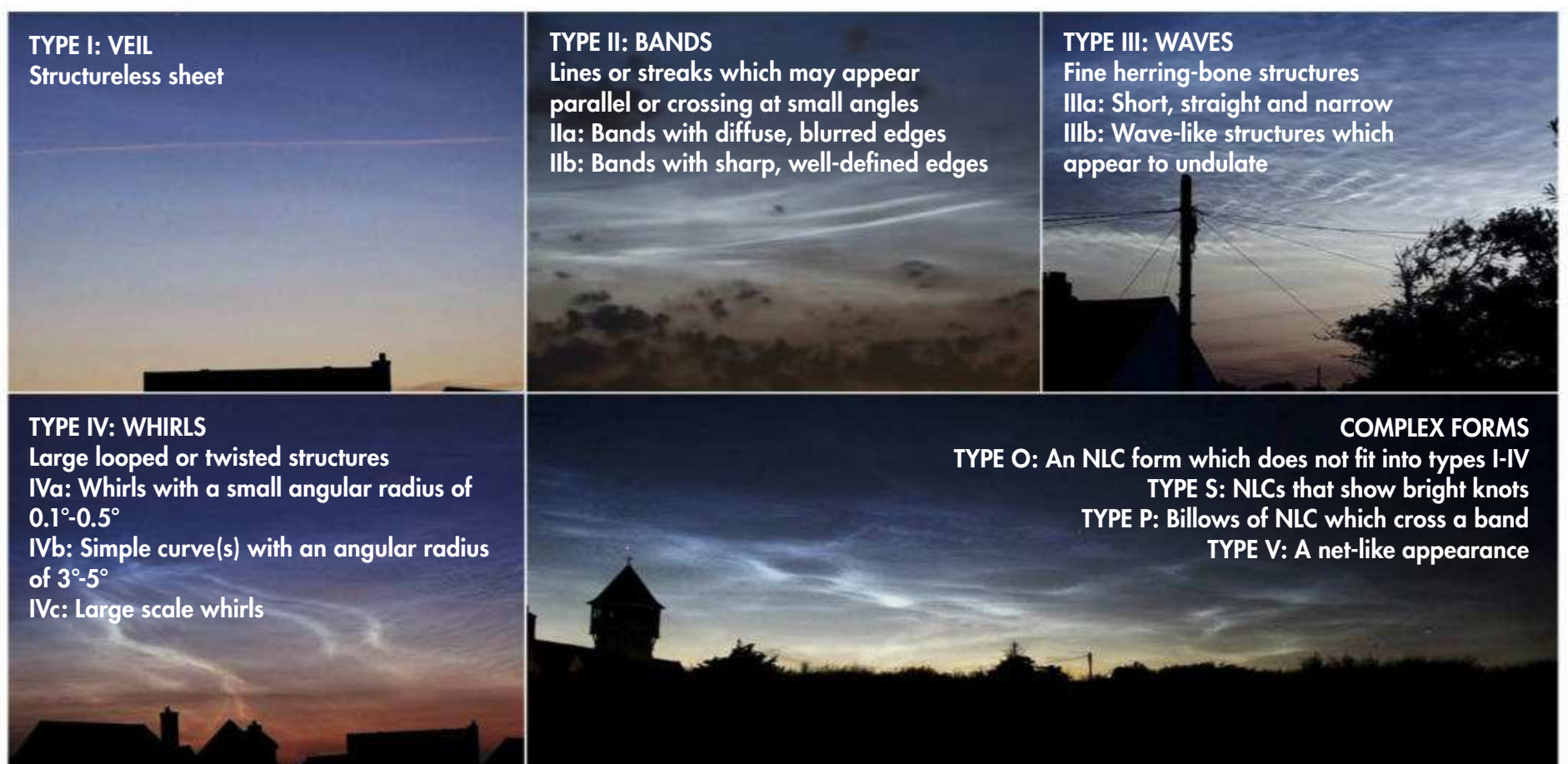


Another feature of interest is how an NLC display develops through the night. If there is a display it normally occurs when the Sun is between 6° and 16° below the horizon. From the UK, displays tend to appear low above the northwest horizon 90-120 minutes after sunset, or above the northeast horizon a similar time before sunrise. If they're extensive, displays can be seen moving from the northwest through north and into the northeast. Typically described as a low-altitude phenomenon from the UK, under certain situations NLCs have been seen to extend to high altitudes, even overhead.

The appearance of NLCs in any particular year cannot be predicted with accuracy. Links to external influences, for example the 11-year solar cycle, can only be established by vigilant NLC patrol watches in which negative sightings have just as much importance as positives. 

▲ High altitude NLC display recorded on the morning of 21 June 2017. Stars in the image help to ascertain the altitude of various structures

▼ Photography of NLC displays can be enhanced by maintaining detailed observational records of the structures recorded



# RINGS

## around the Solar System

Our cosmic neighbourhood is an abundance of hoops and halos.

**Jane Green** finds out what makes the Solar System round

**W**hether comprised of silicates, icy dust, water ice or rock and whether micrometre, multi-metre or millions of kilometres in size, all the rings in

our Solar System are detritus, relics of our star's protoplanetary disc. They litter a system where 'roundness' rules. The spinning Sun, planets and moons are all near-spherical. Why? Were rings instrumental? Are rings relevant or mere rejects? Do discs denote rise or demise, or neither?

One very familiar ring was spawned some 4.6 billion years ago from a fragmenting cool molecular cloud. Over the next 100,000 years gravity, gas pressure, magnetic fields and rotation flattened this spinning nebula into our nascent Solar System's protoplanetary disc. Peppered with pre-planetary material and anchored by its young T Tauri protostar, the disc stretched out to 200 Astronomical Units (AU) in diameter (where 1AU is the average distance between Earth and the Sun). Another 50 million years saw rising temperatures fuse hydrogen in the star's core, allowing energy to counteract gravitational contraction and ultimately spawn our Sun.

The legacy? A spherical reservoir of trillions of leftover, loosely bound

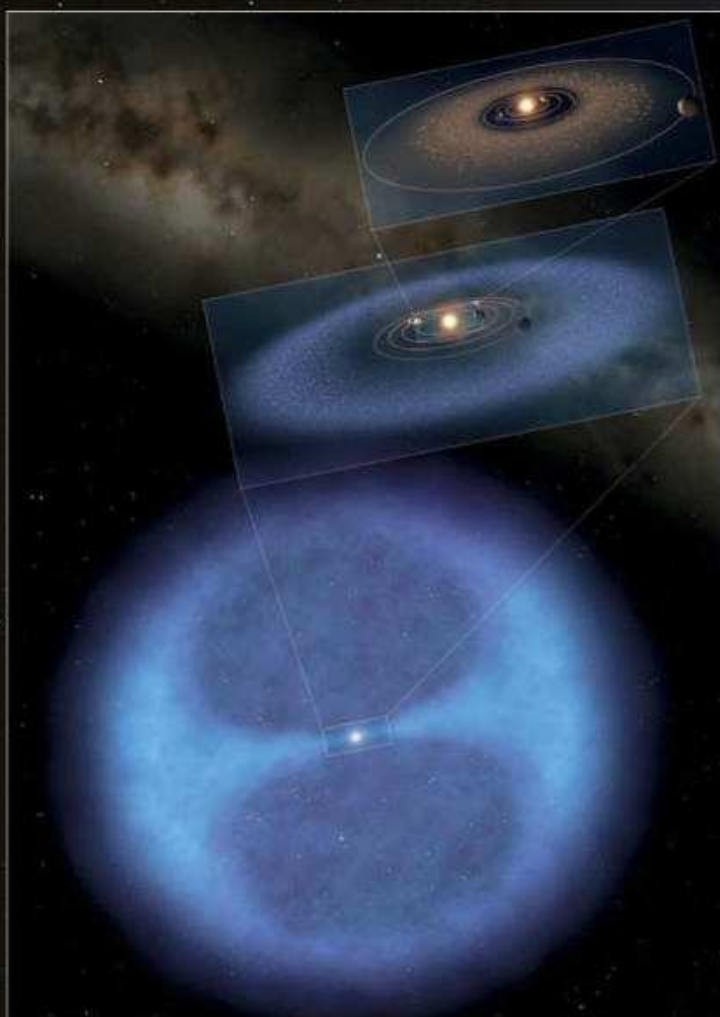
▼ The Oort cloud (bottom) surrounds the Kuiper Belt (middle) which surrounds the Solar System (top) – it's like Russian dolls

comets known as the Öpik-Oort Cloud, stretching 50,000AU to 200,000AU from our main sequence star. Like a Russian Matryoshka doll, within this trundles another hypothesised ring, the doughnut-shaped Hills Cloud. Spanning as far as perhaps 30,000AU from the Sun, this swarming disc of icy debris could contain 20 trillion comets – the largest concentration in our neighbourhood – and, along with the outer cloud, host the so-called long-period comets, which have orbits greater than 200 years.

### The Scattered Disc

Inside this ring, closer to our Sun, lies another: the diaphanous Scattered Disc, home of the short-period comets, which have orbits shorter than 200 years. Once too distant and circling too slowly to be accreted into larger bodies, these icy Scattered Disc Objects are survivors of the solar nebula: a remnant of the molecular cloud from which our Solar System formed. Later strewn by a gravitational interplay between the gas giant planets – primarily Jupiter, Saturn and a migratory Neptune – these sentinels still exist in a smaller 50-150AU ring defining the Solar System's frozen outer realms.

Zooming in to some 50AU from our Sun, the inner Scattered Disc meets another ring, the outer Edgeworth-Kuiper Belt extending inwards to ►



An artist's impression of the  
protoplanetary ring that  
gave birth to the Solar System



**ABOUT THE WRITER**

Jane Green is a  
presenter, science  
writer and author  
of the *Haynes  
Astronomy Manual*

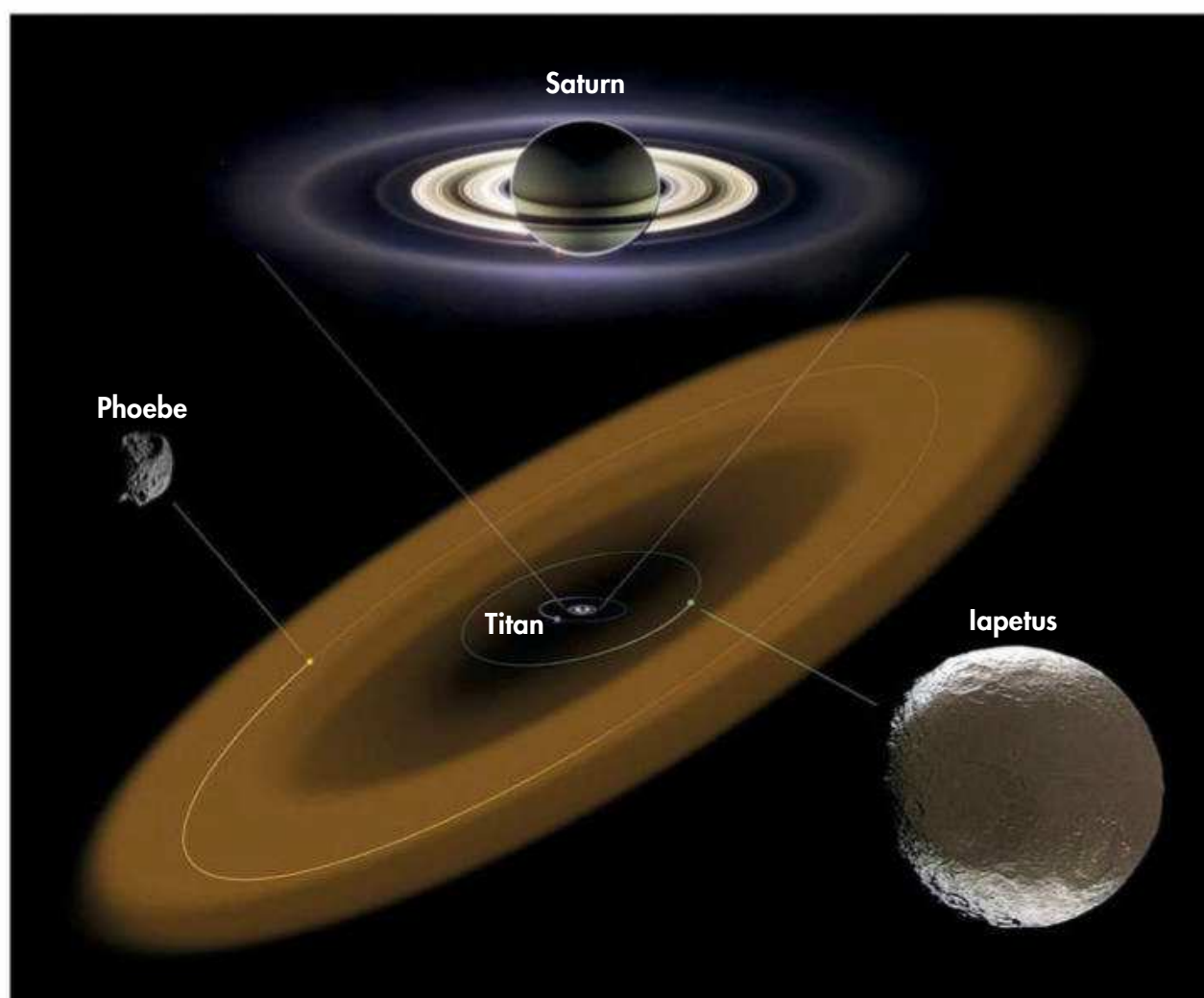
► Neptune. Here dwell three of the five dwarf planets: Pluto, Haumea and Makemake, each rolling alongside other smaller orbiting bodies. We meet another narrow dense and newly discovered ring, this time around rugby ball-shaped Haumea. A possible result of a collision between its moons Hi'iaka and Namaka, this ring was discovered occulting distant star URAT1533-1825 in January 2017, double-dimming its light by an astonishing 50 per cent.

Spiralling yet further inward from these Trans-Neptunian Objects – those minor planets populating the Kuiper Belt, Scattered Disc and Oort Cloud – we spy Neptune, Uranus, Saturn and Jupiter. Recognise a theme? Yet more rings. Neptune has six, each tenuous and dusty. Uranus, with its arcs and interspersed dust bands, has 13. The most extensive ring system, of course, surrounds majestic Saturn. Sculpted by gravity, resonances between embedded 'shepherd' moons and other phenomena, these rings are exquisite, the water ice they are made up of pushed, pulled and pummelled into spiral density waves, cliffs, accreting moonlets, gaps, spokes and other dazzling derivations. Yet these are but trivial compared to the Phoebe dust ring. This Saturnian circle spreads a whopping 6 to 12.5 million km and is sparsely peppered with dark particles measuring just one-tenth to one-fifth the average width of a human hair.

## Circling Jupiter

As we dive ever deeper into our Sun's gravitational well we discover the lesser-known Jovian rings: a system of 100 to 1,000-year-old self-replenishing dust. Looming 10,000km above Jupiter's ring plane spins the thick inner torus or 'halo', girdled by an outer razor-thin ring some 30km deep. A third ring's inner edge furnishes a faint 600km-thick cloud, or bloom, fed by dust from moons Metis and Adrastea, and other impacting bodies.

Concentricity continues. The main ring smears into two wider 'gossamer rings', Amalthea and Thebe, so-named after the Jovian moons from whose material they are composed. Beyond is the whiff of a primordial arc of dust detected by NASA's New Horizons probe, hinting at the dawn of yet another ring. And cradling them all is a bagel-shaped torus of ionised sulphur, oxygen, sodium and chlorine. This dynamic hoop centres on Jupiter's volcanic satellite Io. Io is tilted with respect to Jupiter's equator and its own orbital plane, and as it completes its 1.8-day orbit, swooping above and below the hoop's core, neutral atoms and molecules are stripped from its tenuous atmosphere



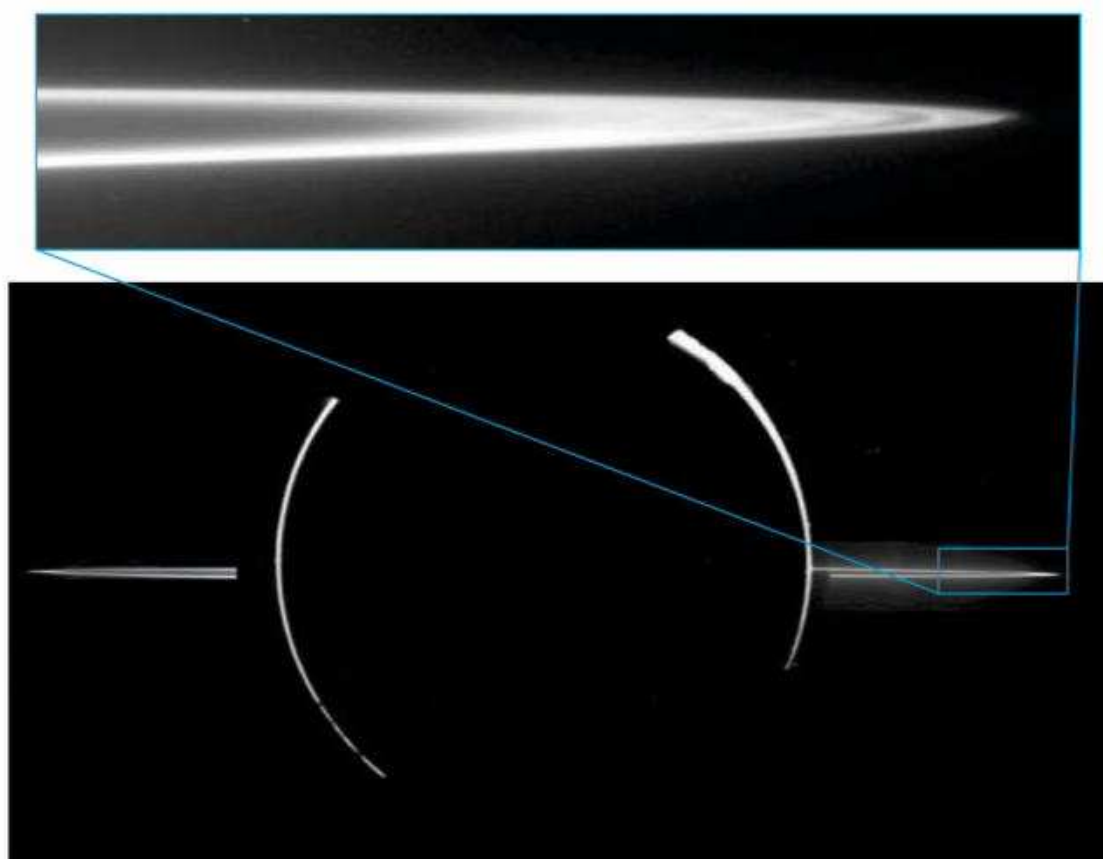
and companion neutral doughnut-shaped cloud. Energised and accelerated by the gas giant's mighty magnetosphere and speedy 10-hour rotation, this miasmic ring of plasma co-rotates at some 74 km/s.

So, just the four gas giant ring-systems then, plus those of tiny Haumea? No! Rings reside almost everywhere in our Solar System's rubble-ridden realms. Before Haumea's were discovered astronomers found rings around the 250km-wide asteroid 10199 Chariklo and the 200km-wide minor planet 2060 Chiron. These double-ringed rocky relics orbit between Jupiter and Neptune, their discs diminutive but still beautifully formed.

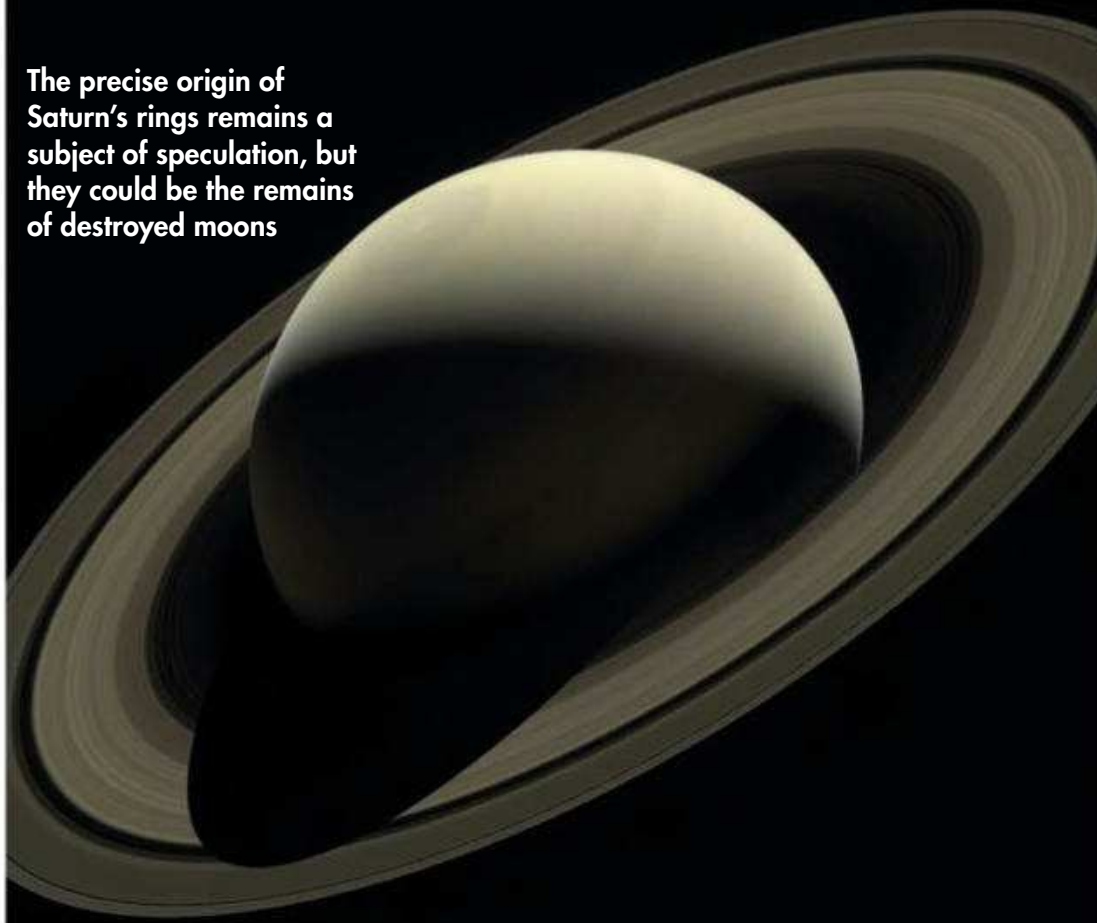
So why rings, and why so many? The culprit? Gravity and its governance. This, and competing

▲ Saturn's Phoebe dust ring has a diameter the equivalent of 300 Saturns

▼ Whilst not as visually stunning as Saturn's rings, Jupiter's have a complex beauty of their own



The precise origin of Saturn's rings remains a subject of speculation, but they could be the remains of destroyed moons



## CLOUDS, BELTS AND BANDS

From the biggest to the smallest,  
how the Solar System's rings compare

### Öpik-Oort Cloud

Radius: 200,000AU

Width: 150,000AU

Discovered by: Ernst Öpik, Jan Hendrik Oort (theorised)

### Hills Cloud

Radius: 30,000AU

Width: 28,500AU

Discovered by: JG Hills

### Scattered Disc

Radius: 100AU

Width: 50AU

Discovered by: David C Jewitt, Jane Luu (first object)

### Edgeworth-Kuiper Belt

Radius: 55AU

Width: 30AU

Discovered by: David C Jewitt, Jane Luu

### Main asteroid belt

Radius: 3.2AU

Width: 1AU

Discovered by: Giuseppe Piazzi (who discovered Ceres, the first observed object within the belt)

### Rings of Saturn

Main rings:

Radius: 480,000km (outermost)

Width: 410,000km (inner to outer)

Discovered by: Christiaan Huygens

### Phoebe dust ring:

Radius: 12,500,000km

Width: 4,766,000km

Discovered by: Anne J

Verbiscer, Michael F Skrutskie,

Douglas P Hamilton

### Rings of Jupiter

Radius: 226,000km (outermost)

Width: 134,000km (inner to outer)

Discovered by: Voyager 1

### Rings of Neptune

Radius: 62,900km (outermost)

Width: 22,000km (inner to outer)

Discovered by: Voyager 2

### Rings of Uranus

Radius: 51,150km (outermost)

Width: 9,300km (inner to outer)

Discovered by: James L Elliot, Edward W Dunham, Jessica Mink

### Rings of Haumea

Radius: 2,287km

Width: 70km

Discovered by: 10 central European observatories

### Rings of 10199 Chariklo

Radius: 410km (outermost)

Width: 20km (inner to outer)

Discovered by: 10 telescopes in Argentina, Brazil and Chile

### Rings of 95P/Chiron

Radius: 320km (outermost)

Width: 20km (inner to outer)

Discovered by: Amanda Bosh, Jessica Ruprecht, Michael Person, Amanda Gulbis

▼ It's not just large bodies that have rings. Here is a trio of mini ringed bodies: (Top to bottom) Haumea, 10199 Chariklo and 2060 Chiron



forces, shaped our nascent Sun and protoplanetary disc. It still does. Any objects orbiting within a planet's gravitational threshold – known as the Roche Limit – endure tidal forces overwhelming their own gravity, which prevents coalescence into a moon. If an orbiting moon breaches that limit, tidal stresses tear it apart. A cosmic impact will rip a moon asunder. There are meteoroid strikes. Cryovolcanic activity creating ejecta. The fallout? Gravitationally corralled rings.

This ring-fest overview halts some 2AU from the Sun, in the raggedy bracelet of the main asteroid belt circling between Jupiter and Mars. Meet billions more pebbles, larger asteroids – Vesta, Pallas and Hygiea – and the 950km-wide dwarf planet Ceres. If the Martian moon Phobos smashes into the Red Planet, there will be rubble. Constrained by gravity, it may eternally circle or coalesce into another spherical moon, to be again impacted.

Rings represent beginnings, middles and ends, their evolution evident not just around our host star, but others in the Milky Way Galaxy and beyond. **S**



## SKILLS

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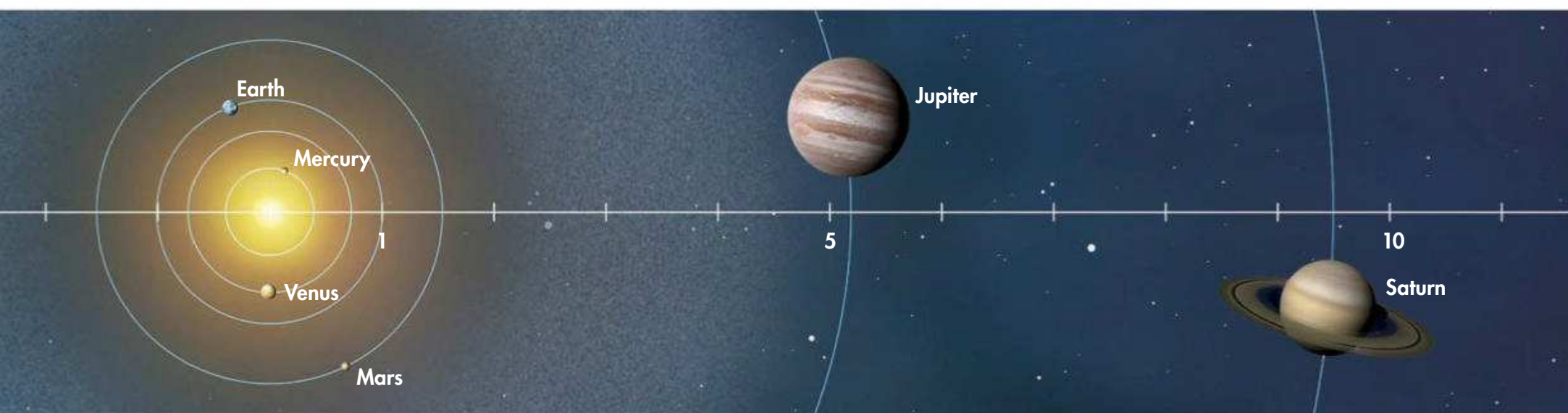
# The Guide



With  
**Dave Golder**

A quick guide to AUs, lightyears and parsecs

Space is so vast it's measured in a number of specialised units. So what are they?



▲ A to-scale representation of the Astronomical Units of distance from the Sun to Saturn. The distance to Earth's orbit is 1AU

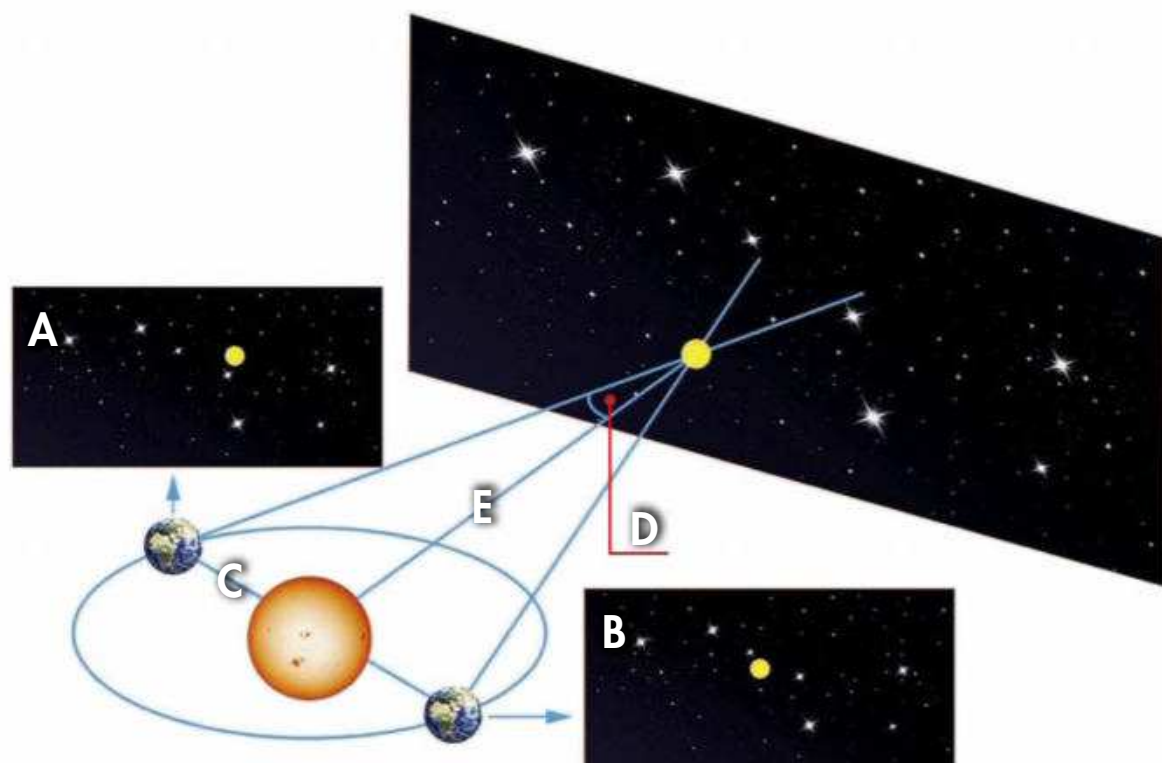
Space is big, really big, as the opening of *The Hitchhiker's Guide to the Galaxy* sagely informs us. The distances between celestial objects are so mindbogglingly vast that specialist units are needed to chart it. To express in miles the distance from Earth to the edge of the observable Universe, for example, results in the unwieldy figure of 270,000,000,000,000,000,000,000 (give or take). Even using mathematical notation to shorten it to  $2.7 \times 10^{23}$ , it's still so esoteric as to be near meaningless. What space needs is really, *really* big units of measurement.

**Astronomical Units**, or AU, are the smallest, simplest and oldest of these astral measurements. One AU is equal to the radius of Earth's orbit around the Sun; or, to be more precise, the average radius since Earth's orbit is elliptical.

An AU is defined as 149,597,870,700m (about 93 million miles), a value officially set by the International Astronomical Union (IAU) in 2012. Astronomers have been trying to calculate the distance from

Earth to the Sun ever since, in the 3rd century BC, Archimedes estimated it to be around 10,000 times Earth's radius, or 63,710,000km – so he was nearly halfway there. Not bad for someone who lived 2,000

years before the telescope was invented. It wasn't until 1695 that Christiaan Huygens made the first close guess of 24,000 Earth radii (152,904,000km) though some science historians dismiss his calculations as more



▲ A and B show how a nearby star appears to move against its background when Earth is at different positions; C is equal to an AU; D is a parallax angle of one arcsecond; E is a parsec

# A matter of scale

A comparison of distances in AUs, lightyears and parsecs

	AUs	Lightyears	Parsecs
The Sun to Earth (or 1AU)	1	0.0000158	0.00000485
The Sun to Neptune	30,047	0.00047	0.14567197
1 lightyear	63,241	1	0.306601
1 parsec	206,265	3.26156	1
Earth to Proxima Centuari	58,064.516	4.25	1.3
Earth to the Andromeda Galaxy	18,102,690,000	2,500,000	780,000
Earth to the edge of the visible Universe	22,888,000,000,000,000	46,000,000,000	14,000,000,000

luck than judgement, preferring to cite Jean Richer and Giovanni Domenico Cassini's rigorously calculated 22,000 Earth radii (140,162,000km) as the first scientifically plausible estimate (despite the fact they were further from the mark than Huygens).

## Lightyears and parsecs

The AU remains a useful unit for distances within the Solar System. But the Solar System is a tiny corner of the Universe and much bigger units are needed once we go beyond it. A **lightyear** is defined as how far a beam of light travels in one year – around 9.5 trillion km. If you want to be precise, the IAU regards a year as 365.25 days making a lightyear 9,460,730,472,580,800m.

The germ of the concept originated with Friedrich Bessel, who, in 1838, made the first successful measurement of the distance to a star outside our Solar System, 61 Cygni. In his findings he mentioned that light takes 10.3 years to travel from 61 Cygni to Earth. He wasn't seriously positing the idea of lightyears as a unit; for one thing the speed of light at the time had yet to be calculated accurately. However, the concept was too enticing to ignore and by the end of the 19th century it was in general use, even if some astronomers ever since – including Arthur Eddington who called it irrelevant – have been sniffy about its use.

So why is the lightyear useful? Take our nearest extrasolar star, Proxima Centauri. Instead of expressing its distance in miles (38,624,256,000,000) or AU (258,064.516) – values too vast to grasp meaningfully – we can say it's 4.25 lightyears away. Our closest neighbouring galaxy, Andromeda, is over two million lightyears away.

So the lightyear is like metrology by metaphor, similar to "areas of rainforest the size of Wales". But while the general public embraces the lightyear because it's such an easy concept to get your mind around,

scientists, of course, prefer a unit that needs a diagram to explain. Officially, a **parsec** is the distance at which one astronomical unit subtends an angle of one arcsecond, which would leave most people going, "Huh?" It's not quite as arcane as it sounds.

The parsec is based on parallax vision. For a practical example, hold your finger in front of your eyes, then alternate closing each eye; the finger appears to leap from side to side in relation to the background.

Now imagine this on a cosmic scale. If Earth is on one side of the Sun, when we look at a nearby star, it will appear to be in one position in respect to the stars in the background. Six months later, when Earth is on the extreme other side of the Sun, that same star will appear to be in a slightly different position against its background.

We're talking tiny amounts of difference, measured in arcseconds (of which there are 3,600 in one degree of sky). A parsec is the distance to a star that would appear to move

by two arcseconds over a six-month period; or, to put it another way, one arcsecond as Earth travels the linear equivalent of 1AU. Hence the name: PARallax, arcSECond. The term first appeared in a 1913 paper by English astronomer Frank Dyson.

A parsec is roughly 30 trillion km, or a little over three lightyears. Returning to our previous examples, this places Proxima Centauri 1.3 parsecs away from us, and the Andromeda Galaxy nearly 800 kiloparsecs. Hang on – *kiloparsecs*? Yes, even parsecs aren't huge enough for some scales, so they're upscaled to kiloparsecs, megaparsecs and gigaparsecs (one thousand, one million and one billion parsecs respectively).

Which means we can now inform you that the edge of the visible Universe is 14 gigaparsecs away without wearing out the zero key on our keyboard. **S**

*BBC Sky at Night Magazine's production editor DAVE GOLDBER, feels very small*



For many decades, those who understood such things would sigh wearily when pulp sci-fi authors mistook lightyears for a measure of time, rather than distance. However, in a well-known gaff in the original *Star Wars* (1977), George Lucas's script

mistakes a parsec for a measure of time, when Han claims the Millennium Falcon "made the Kessel Run in less than 12 parsecs". The recent *Solo* film (rather unconvincingly) tried to retroactively explain away this discrepancy with some nonsense about shortcuts.

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With  
**Mark Parrish**

# How to...

## Make a battery-free focuser

A DIY device for remotely adjusting your telescope's focuser

The completed battery-free focuser ready for use



Focusing your telescope can be a tricky affair; even the lightest touch can introduce vibrations that blur your view. This can be a particular problem when you're imaging planets at high magnifications, making it difficult to find the 'sweet spot' when you're focusing in and out either side.

This month's project is an inexpensive, motorised drive that you can attach to your existing focuser. A hand controller, linked via a cable, is used to operate the unit without any need to touch the telescope, and the whole thing works without batteries.

Our design utilises a pair of small servos (similar to the kind often found in remote-controlled models). These servos are really cleverly packaged DC motors with built-in gearboxes to slow them down and increase the torque they can apply. They also have internal electronics that are typically used to determine their position. In normal use, a series of pulses are sent to the servo and the electronics interpret these to move to a known position or rotate at a

particular speed. Most servos are designed to turn between 0° and 180°, but the FS5106R version is designed for continuous rotation, which is just what we're after. If you have some existing 'normal' servos that you want to use it is possible, with care, to remove the spurs from the internal gears, which frees them up to turn fully; there are internet guides describing how to do this.

As we have no need for them we removed the little circuit boards from inside the cases and soldered a twin core cable directly between the motors. This may seem strange but it is really just the gears and motors that we need to use.

### Generating current

It is a well-known fact that if you turn the spindle of a DC motor you create a mini generator. Turning a wheel or handle attached to one of the servos turns its gears, which causes the motor inside to rotate quite fast. We can call this the 'input servo'. This movement generates just enough current to drive the second servo connected to the other end of the cable. This is our 'output servo', which will be connected to

## TOOLS AND MATERIALS



### Tools

Coping saw; drill and bits (8mm, 4mm, larger bit to suit existing focuser knob, plus smaller bits for pilot holes); soldering iron; pliers

### Materials

Small piece of good quality 18mm plywood approx A5 size (or thinner layers glued together) and a similar sized piece of 6mm plywood; 3mm acrylic or plywood for servo mount

### Sundries

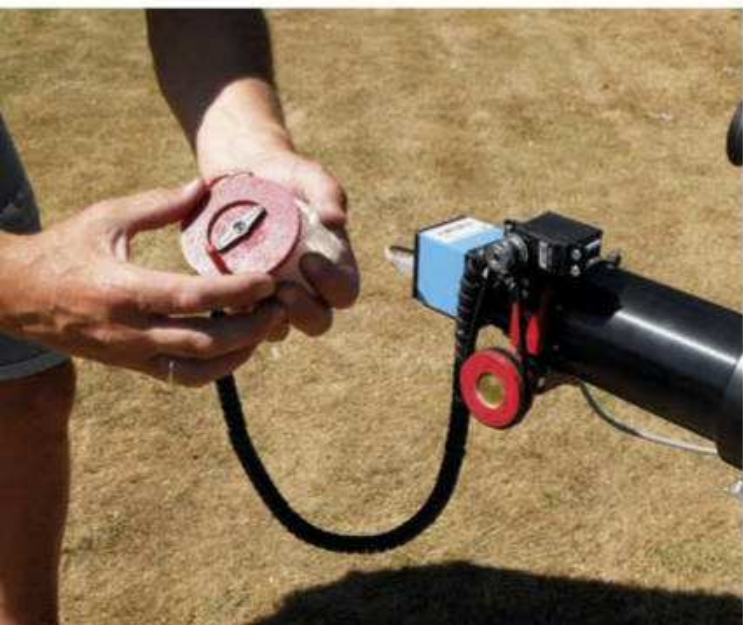
Two FS5106R continuous rotation servos (or similar); five M3x25 screws with suitable nuts; an M3 grub screw and two small self-tapping screws (from servo kit); GT2 belts – one 140T (280mm) and one 75T (150mm); one GT2 20T pulley; a length of suitable cable with at least two cores (we used a telephone cable, for example); small strip of rubber; two long cable ties; two round nails

### Finish

Some spray paints or wood varnish to provide a nice finish

the focuser. Turn the input quickly to generate a fast movement; make small movements to fine-tune the output position.


Reversing the direction affects the output similarly so, with the addition of some drive belts, a bracket and a mounting plate to hold the output servo in position, ►



▲ Turning the wheel on the remote hand unit activates the focuser's drive

► it's not hard to see how to build a simple but effective focussing aid.

Most focusers use a rack and pinion design or a Crayford type of direct drive and both types are adjusted by turning a knob on the end of a shaft. We cut out a round wheel and glued an inside-out GT2 belt round the circumference to create a toothed gear. This is drilled out so that it fits snugly onto the focuser's knob. A bracket designed to hold the mounting plate for the output servo may need a little modification to position the pulley vertically above and in line with this toothed gear, so be prepared to make a few cardboard templates to test the shape before committing. An adjustment slot in the mounting plate for the small fixing screws that hold it to the bracket is useful for taking up any slack in the drive belt.

We mounted our input servo in a small plastic box that once held some wall fixings and attached a plywood wheel. This makes it easy to grip and turn. This part of the design could be further modified to make it even more comfortable and perhaps provide a way to hang it up in a handy place on the tripod when not being used. You might also consider a removable plug for detaching the cable and a quick release method for taking the whole unit off should you wish to change the setup. However you complete it, we are sure you will love the results from this handy device. 

MARK PARRISH is a bespoke designer. See more of his work at [buttondesignco.uk](http://buttondesignco.uk)

## YOUR BONUS CONTENT

Download plans, diagrams and extra photos to help you with this project

## STEP BY STEP



### STEP 1

Unscrew one servo's back (avoid disturbing gears in the top section). De-solder wires to motor and remove the three core cables and circuit board. Solder new cable to motor and refit. Repeat for second servo. You may need to enlarge cable slot to suit new cable.



### STEP 3

It's easier to drill holes in the plywood bracket and servo mount plate before cutting out the fiddly shapes as there's more material to hold. The bracket holes accommodate two trimmed nails, which provide support for the cable ties. Smooth and paint finished parts.



### STEP 5

Make a thicker wheel with a 48mm diameter. Drill the centre to suit the focuser knob. A small hole may be drilled radially to accommodate a grub screw so you can attach it securely. Glue the smaller GT2 belt inside out to the circumference of the wheel.



### STEP 2

Use the downloadable plan/template to mark out parts – adjust shape to suit your focuser (see main article). We used 18mm thick plywood made from some 15mm and 3mm offcuts glued together. Carefully cut out servo mount from thin plywood or acrylic.



### STEP 4

Make a round wheel from thin plywood with a dowel handle for speedy turning. One of the servo attachments that comes with the kit is glued to the centre. Superglue a second attachment to the GT2 pulley (roughing up the surfaces makes the joint stronger).



### STEP 6

Use cable ties passing over the nails to attach the bracket. A rubber strip underneath aids the grip. Make sure the pulley and drive gear are in line before tightening. Fit the larger belt and remove slack before finally tightening the screws on the mount.

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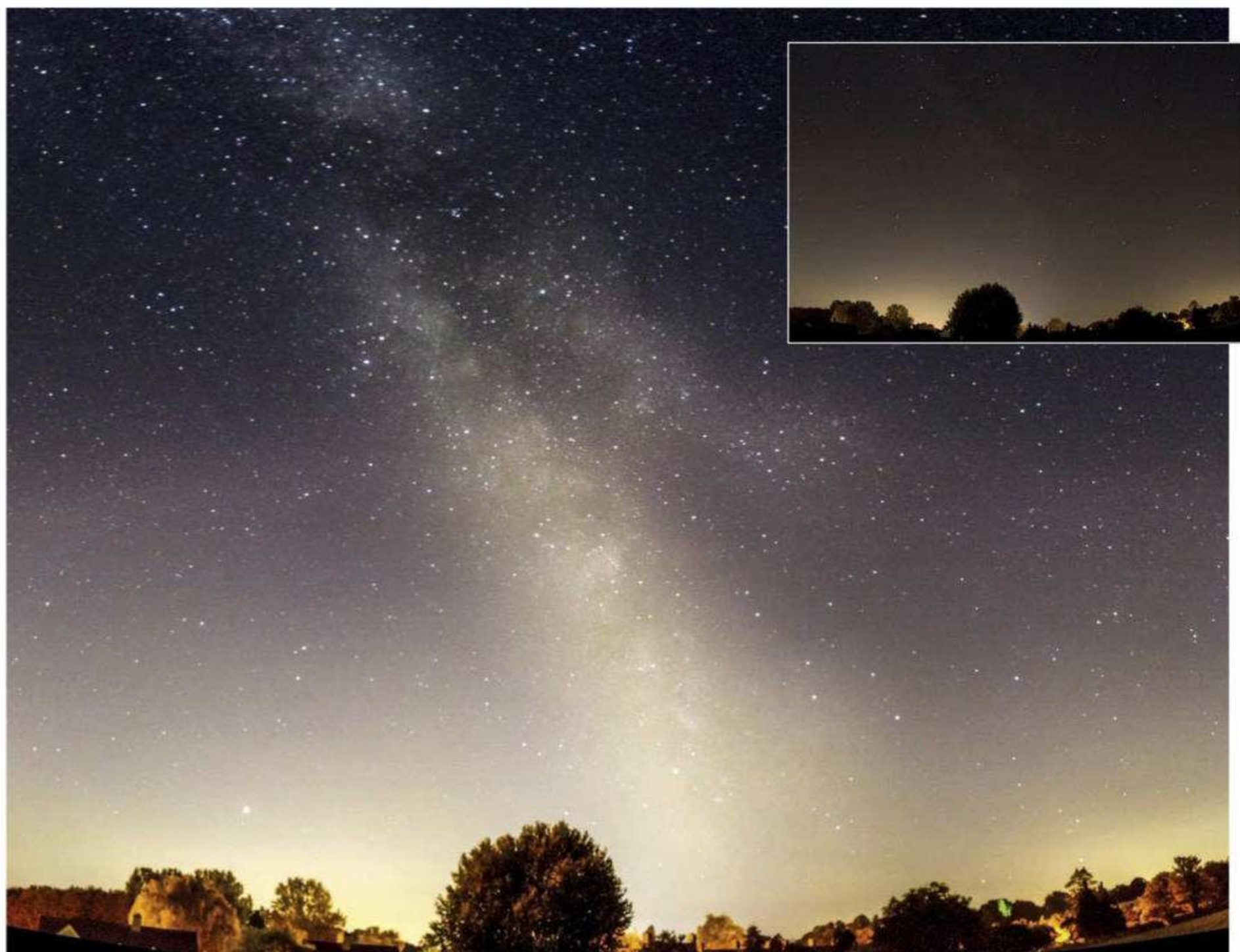
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**Mary McIntyre**

## Combatting light pollution in Lightroom

How to brighten the Milky Way in an urban image without increasing artificial glare too



▲ Inset is the original, preprocessed image, while the larger final image emphasises the Milky Way without letting the human-made glare overpower it

ALL PICTURES: MARY MCINTYRE

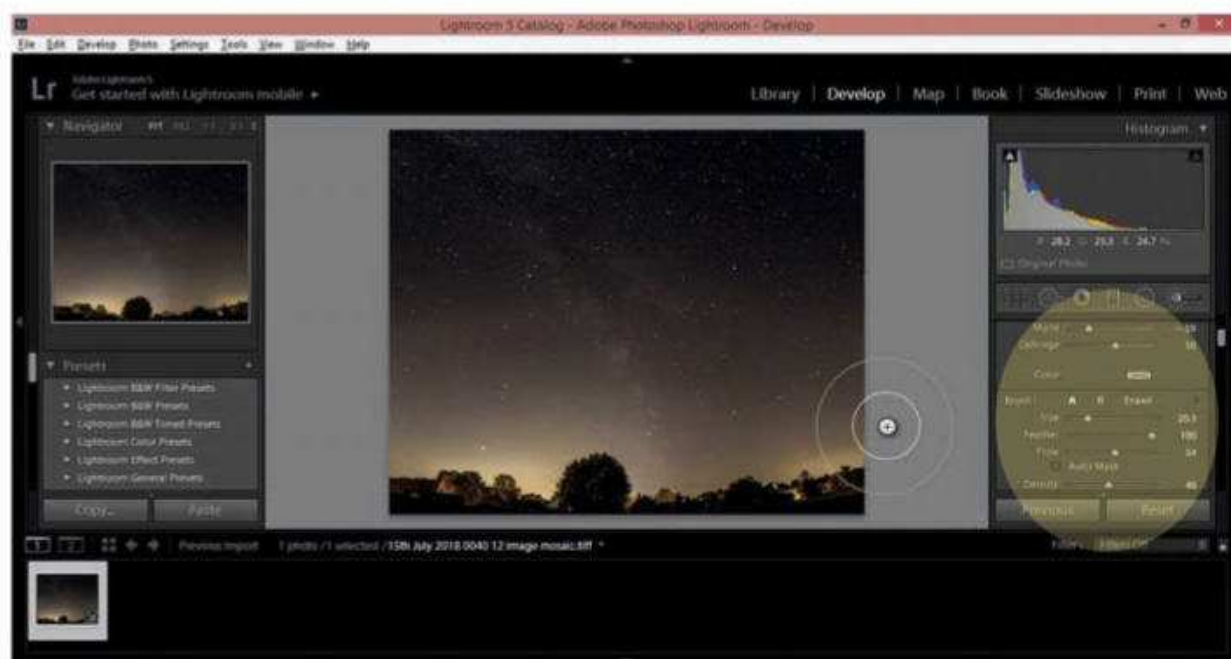
Successfully photographing the Milky Way from a light-polluted location can be tricky because as you increase the exposure time, you also increase the amount of artificial background glare in your image. Image processing is vital to enhance Milky Way images shot under such conditions.

Using the adjustment brush along with a few other features in Lightroom 5 will allow you to selectively enhance the faint structure and colours of the Milky Way without affecting the background.

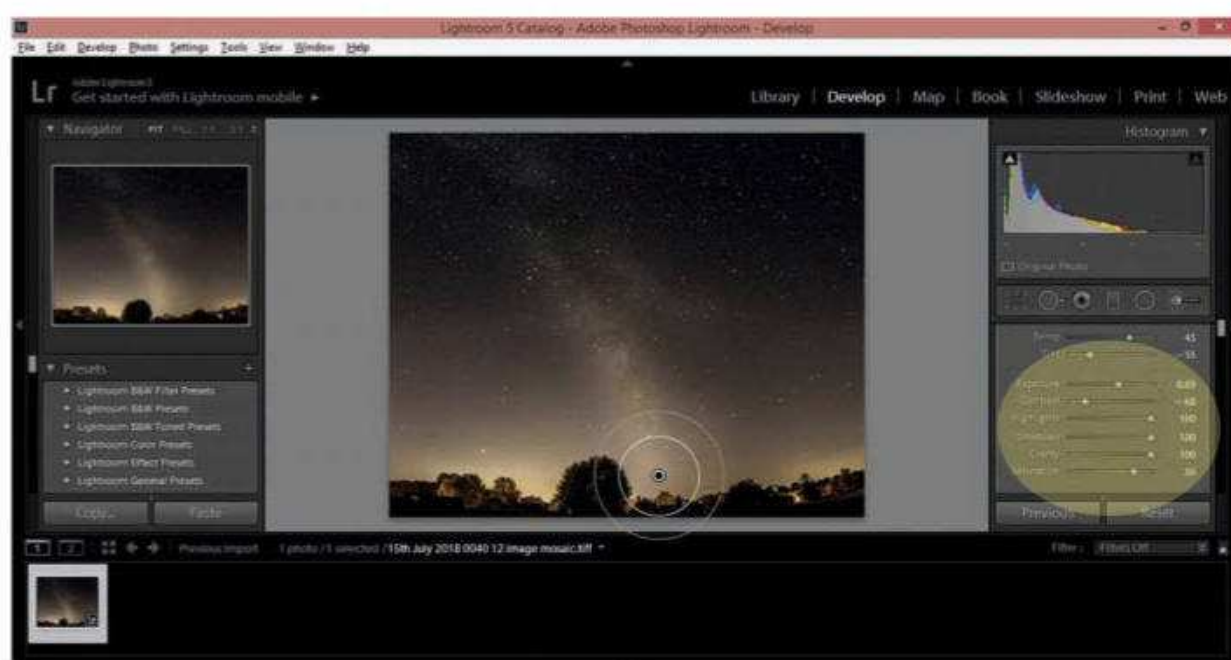
The image we begin with is a 12-pane mosaic of the southern region of the Milky Way, shot over a North Oxfordshire village and facing south towards the light

pollution from Oxford city centre. Each image was shot with a Canon 1100D and an 18-55mm kit lens on a static tripod, taking a single exposure of 20 seconds at ISO 1600, f/3.5. They were stitched together using Microsoft ICE.

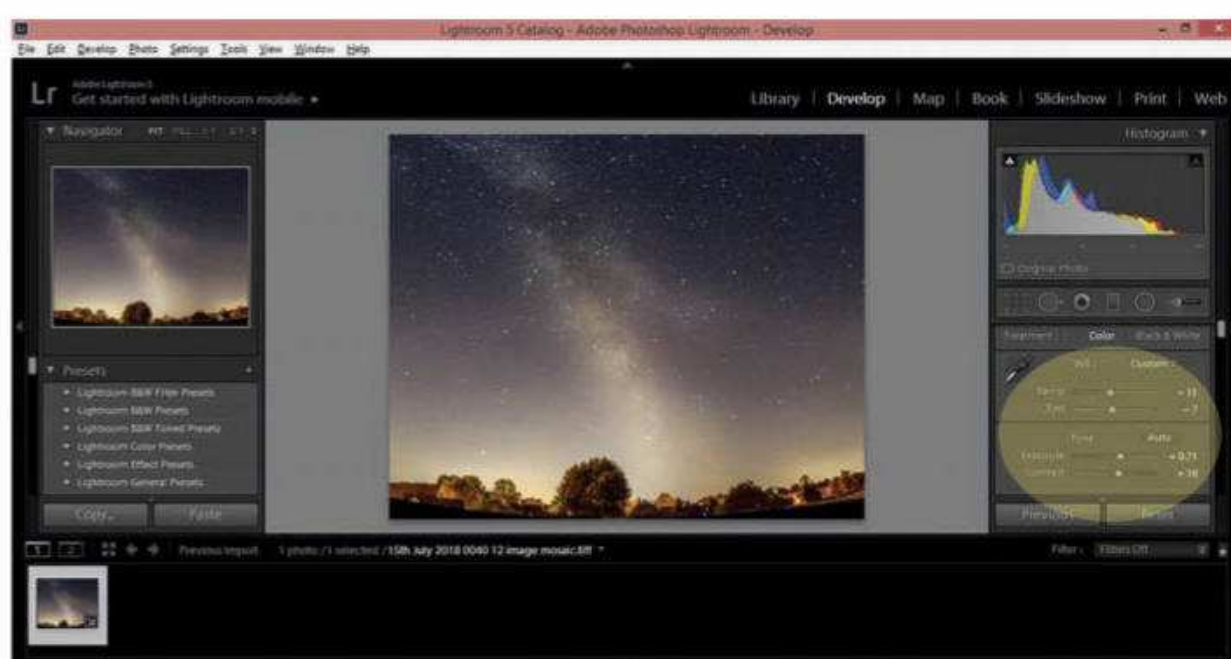
Begin by opening Lightroom 5. In the Library module, open your image by clicking on Import and select your ►



▲ Using a large brush (controls highlighted) with a high feather value to highlight the Milky Way



▲ Changing the colour and temperature (controls highlighted) to make the Milky Way warmer



▲ Adjusting Colour Temperature and Tint (controls highlighted) to compensate for light pollution

► image from the relevant folder. Make sure you are in the Develop module by clicking on Develop at the top right of the screen. Scroll down the sliders until you reach the Presence section. Drag the Clarity slider up to around +74, or until you can start to see some of the Milky Way structure standing out against the background. Next, select the Adjustment Brush by clicking on the icon

on the right-hand side underneath the histogram. You need to make the brush quite large with a large feather area to ensure the adjustments don't leave harsh edges. Here, Brush Size was set to 20.3, Feather to 100, Flow to 54 and Density to 46 (see the image at the top of this page).

The mouse pointer now controls the brush and by left-clicking the mouse, you

will select an area beneath. Gently move along the length of both sides of the Milky Way, making small clicks to highlight the brighter areas. If you keep the mouse button down and colour in the whole thing, you will be left with an ugly bright stripe across the sky; not what you're trying to achieve! Be very gentle and remember you can always go back and add more highlights later.

## Warming things up

Keeping the brush tool open, the sliders on the right-hand side will control only the areas that you have just highlighted. The first stage is to change the colour temperature of the selected areas and warm them up. Here we moved the Temperature to +45 and the Tint to -55. Next, we moved the Exposure slider up slightly, brought the Contrast down a little and moved the Highlights, Shadows and Clarity up to 100. We then increased the Colour Saturation (see the middle photo on the left). With all of these steps, make sure that the Milky Way looks warmer and brighter, but take care not to overdo it and make the image look unnatural.

Exit the brush tool by clicking on Close at the bottom of the brush tool sliders. Now make some tweaks to the entire image using the sliders to the right. By making small changes to the Highlights, Shadows, Whites and Blacks sliders, you can further enhance your image as a whole.

Next, apply some noise reduction to smooth out the image. Scroll down the different groups of sliders on the right-hand side until you reach the Noise Reduction section of the Detail block. Apply only a small amount of noise reduction using the slider as too much will blur the image excessively. Underneath Noise Reduction, increasing the Detail slider will help to preserve detail. If your image is still looking noisy or grainy, bring the Clarity slider back down a touch until you have a smoother result.

For the final step, using the sliders at the top, adjust the Colour Temperature and Tint sliders down slightly to compensate for the sodium light pollution in the background. Then make final tweaks to the overall exposure and contrast (see the bottom photo to the left).

When you're happy, click on File > Export at the top left of the screen to export the image. Use any other editing tool to apply final cosmetic adjustments if required. **S**

Mary McIntyre is a dedicated astro imager based in Oxfordshire

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# Scope DOCTOR



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▲ While good scopes, the Meade NG 90 (left) and ETX 90 (right) have optics that limit your range of observing

***I'm thinking of getting either a Meade NG 90 or ETX 90. Are these suitable for a beginner and how upgradable are they?***

JOHN PLACE

The two telescopes you mention are suitable for beginners but some of your cash will be paying for the electronics in the Go-To mount at the expense of the optics. Although these two are reasonably good telescopes, they are rather limited by their relatively small apertures and long focal lengths of around 1,250mm. As such, they are more suitable for lunar and planetary observations than for more general use.

Larger apertures, which give a much more flexible instrument suitable for a wider range of observations, can be found in the Dobsonian telescope design. You have to point them manually, but they are very simple and intuitive to operate. However, the big advantage here is that all your money will go into the optics which, at the end of the day, is what allows you to observe celestial objects at their best.

An image of Mars showing colour fringing, which can be fixed with an atmospheric dispersion corrector



***I have a Sky-Watcher 200PDS with a DSLR and a 2x Barlow. However, my images of planets have coloured fringes on either side. Do you know how I can eliminate the effect?***

RICHARD WHITE

Your photographs show an aberration known as atmospheric dispersion which is particularly noticeable in planetary images captured using larger aperture telescopes.

Dispersion is the displacement of the different colours of light received from celestial objects as it passes through Earth's atmosphere. The atmosphere acts in a similar way to a prism, separating white light into its component colours. The colour dispersion we see here is caused by differential refraction, where shorter wavelengths of light (blues) are deflected to a greater extent than longer wavelengths (reds). The lower the object appears in the sky, the more noticeable the effect as the light has to

pass through more of the atmosphere than it does at higher altitudes.

The planets are currently at very low altitudes, exacerbating the problem, so you could simply wait until they're higher in the sky. However, optics can also come to the rescue. Atmospheric Dispersion Correctors (ADCs) use pairs of prisms to negate the 'prism' effect of the atmosphere. Examples include the ZWO 1.25-inch ADC, the Pierro Astro ADC and the Altair Astro ADC. However, you will need to check that you can still achieve focus with the extra length of the ADC inserted in the light path as Newtonian reflectors are notorious for not having sufficient inward travel of the focus tube when accessories are added.

## STEVE'S TOP TIP

***What is a diagonal used for?***

The eyepieces on Newtonian reflectors generally remain at a reasonably comfortable viewing height irrespective of where they're pointing. But as refractors and Cassegrains tilt up in altitude their eyepieces get lower and lower, making them harder to look through. This is where a diagonal comes into play.

A diagonal is a small triangular attachment, usually incorporating a small surface-coated mirror set at 45°. The diagonal bends the light collected by the telescope through 90° before projecting it into the eyepiece. This simple attachment makes it much easier to observe because now you can view looking down into the telescope rather than up into it.

STEVE RICHARDS is a keen astro imager and an astronomy equipment expert

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# Reviews

Bringing you the best in equipment and accessories each month, as reviewed by our team of astro experts

## HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

- ★★★★★ Outstanding
- ★★★★☆ Very good
- ★★★☆☆ Good
- ★★★☆☆ Average
- ★★★☆☆ Poor/Avoid

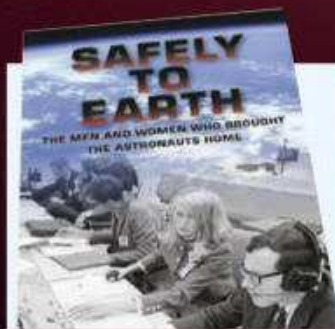
90

The substantial but surprisingly light Sky-Watcher Evostar 150ED DS-Pro could soon be topping your must-have list



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## This month's reviews



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### BOOKS

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**104** A red light torch, solar filters and a lot more

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# FIRST LIGHT

See an interactive 360° model of this scope at [www.skyatnightmagazine.com/ev0150ed](http://www.skyatnightmagazine.com/ev0150ed)



## Sky-Watcher Evostar 150ED DS-Pro refractor

WORDS: TIM JARDINE

The popular Evostar 120ED's bigger, bolder but not much pricier sibling has arrived

### VITAL STATS

- **Price** £1,699
- **Optics** Multi-coated ED doublet
- **Aperture** 150mm (6-inch)
- **Focal length** 1,200mm (f/8)
- **Tube length** 1.3m
- **Focuser** Dual-speed Crayford
- **Extras** Tube rings, T-ring, T-thread adapter
- **Weight** 9.5kg
- **Supplier** Optical Vision Ltd
- **www** opticalvision.co.uk

### SKY SAYS...

Despite some niggles, at the price this sets some new benchmarks for amateur scopes

Anticipation and excitement have surrounded the launch of Sky-Watcher's Evostar 150ED DS-Pro, a new, 6-inch, f/8 refractor. Competitive pricing has also caught the astronomy community's attention, especially among those familiar with the impressive quality of the optics in the smaller, 120ED Evostar. As this new scope has the potential to be an excellent all-rounder, we decided to test it across a number of tasks: planetary and lunar viewing; double stars; deep-sky observation; and photographic performance.

The first thing that strikes you is the size of the thing, but thanks to the aluminium tube it's surprisingly lightweight and easy to handle. To help with the balance we fitted our 50mm finderscope to the shoe provided, and – after some speedy basic collimation – we decided to use the new Moon period to first try some astrophotography, using an optional 0.85x focal reducer on loan for the review.

DSLR cameras fit directly onto the focal reducer with the supplied Canon T-ring. When we tested this configuration out on a star field, the result was a very impressive flat field, with good, round stars right into the corners of our full-frame DSLR, and only minor vignetting. Targeting the Dumbbell Nebula, M27, just 40 minutes' worth of 45 second exposures revealed quite reasonable details and, importantly, no annoying colour rings on bright stars. We went on to photograph NGC 7789, Caroline's Rose, and NGC 6992, the Eastern Veil Nebula, again with pleasing results.

Swapping to our monochrome CCD camera meant we could no longer use the reducer, and without it the star shapes elongated a little in the corners of our small ICX694 camera sensor. On the plus side, the CCD allowed us to test the colour correction of the doublet lens in the 150ED. After finding the point of sharpest focus through a luminance filter, we used parfocal filters to take pictures through red, green, blue and narrowband

filters. The results were very good; close to the best that can be expected from a doublet lens.

Excited by the scope's performance so far, we were keen for some time at the eyepiece, but patiently used two nights of limited summer skies for some narrowband imaging. Just four hours total exposure was enough to reveal the very faint outer gases of the Dumbbell Nebula under average skies.

### Observing the planets

With four major planets on offer, we could no longer resist a visual session, and fitted our 2-inch diagonal. Under twilight conditions Venus showed its phase well, our 4.5mm eyepiece giving a just-about acceptable 266x magnification. At best focus we could barely detect any false colour on the bright edge, just the standard red blue effects of atmospheric refraction.

As it darkened we moved to Jupiter and were admittedly a little disappointed at the initial view. It seemed to lack contrast and surface definition, even at 120x. Of course, this season Jupiter is very low, and softer views might be expected, so giving the scope the benefit of the doubt we decided to do a star test instead. Our green filter and 4.5mm lens ►





## 6-inch doublet lens

Aperture is king, they say, and at six inches in diameter the Evostar 150ED DS-Pro likely presents the maximum manageable size of refractor for many amateurs. The doublet lens is multi-coated and displays a purplish hue. Photographic tests showed no sign of unwanted reflections or artefacts, and visual star tests demonstrate that the lens cell holds the glass without evidence of skewing or pinching, even through temperature drops of over 10°C. The large aperture makes finding fainter objects easier, and even with moonlit

skies and moderate light pollution we could observe both major sections of the Veil Nebula complex with our OIII filter and 21mm eyepiece. Meanwhile, planetary nebulae such as M57 and M27 stood out really well from the background sky. Globular and open clusters were sharp and clear, and bright star Vega showed only the faintest trace of false colour as the seeing varied. Lunar views during steady seeing showed good detail in crater walls and we easily picked out the main craterlets within the crater Plato.

## Tube rings

Dedicated tube rings mounted on a green Vixen-style dovetail provide a stable platform and, feature a 1/4-20 thread bolt and clamping ring for accessories. Upgraded CNC-machined rings are available on a wider, Losmandy dovetail, appealing to those using the 150ED for astrophotography.

## Storage case

Safely storing and transporting the Evostar 150ED is made easier thanks to the large aluminium case it comes in. Measuring 140x39x29cm, the locking, padded case contains helpful cut-outs for accessories and eyepieces, and has handles at either end to make carrying it easier. The combined weight is around 24kg.



## Size and balance

Handling and mounting long telescope tubes can sometimes be tricky and heavy accessories at one end can exert a lot of leverage on a mount. With the end cap removed, and a finderscope and star diagonal with medium eyepiece in place the balance point is roughly at the halfway point of the tube.



# FIRST LIGHT

## SKY SAYS...

Now add these:

1. 0.85x reducer-corrector
2. 2-inch/50.8mm dielectric star diagonal
3. 9x50 finderscope

► gave a round star with concentric diffraction rings, but 1mm of defocus either way gave a sharper pattern.

Returning to Jupiter on subsequent nights gave similar, slightly soft results but planetary viewing conditions were far from ideal. In comparison to our own Sky-Watcher 150ED Esprit, the Evostar

demonstrated less contrast and definition in the equatorial bands.

On double stars the 150ED was a delight. It revealed very clean, wide splits for both Epsilon (ε) and Iota (ι) Cassiopeia. At 533x we even managed to bag the very close double Zeta (ζ) Herculi, which is extra tricky as the small companion resides in the first diffraction ring.

With six inches of clear aperture, optimised colour correction, impressive photographic performance and an attractive price, the 150ED DS-Pro may well set a new benchmark for must-have telescopes. **S**

## Verdict

Build and design	★★★★★
Ease of use	★★★★★
Features	★★★★★
Imaging quality	★★★★★
Optics	★★★★★
OVERALL	★★★★★



▲ M27 using a Canon EOS 6D at ISO 2500, using 39' of 45" exposures



▲ M27 in narrowband using 20 min exposures: 2hr 20' of Hα; 1hr 40' OIII



◀ Lunar craters with a DMK camera and 2x Barlow; 30fps, low lunar elevation, best 60 per cent of 4,000 frames



▼ NGC 6992 using a Canon EOS 6D at ISO 2500; 39' of 45" exposures



## Focuser

A simple, non-rotating, dual-speed Crayford focuser is fitted. Focusing is a smooth process, but our test version slipped when used with a heavy camera or eyepiece and required adjustment. The locking screw had the annoying habit of shifting focus slightly when locked, which made astrophotography in particular more difficult.

## Dewshield and tube

The lightweight tube features a collimatable lens cell and a fixed, large dewshield with 200mm of dew and stray light control. Within the matte black tube are graduated baffles, which help reduce unwanted incidental light and improve contrast, while the outside has an attractive metallic black finish.

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# FIRST LIGHT

See an interactive 360° model of this mount at [www.skyatnightmagazine.com/LX2track](http://www.skyatnightmagazine.com/LX2track)



## Omegon MiniTrack LX2 tracking mount

WORDS: STEVE RICHARDS

The power to track stars is in your own hands... literally, with this clockwork device

### VITAL STATS

- **Price** £109
- **Payload capacity** 2kg
- **Latitude adjustment** Adjustable wedge or pan-and-tilt tripod head required
- **Tracking rates** Sidereal
- **Power requirements** Clockwork, wound by hand
- **Tripod** Not supplied
- **Extras** Ball-and-socket head, polar finder tube, 1/4-20 thread adaptor, spanner
- **Weight** 774g with ballhead
- **Supplier** Astroshop.de
- **Tel** 0049 8191 940491
- **www** astroshop.de

Historically, the drives and gears used to motorise telescope mounts have been known as 'clock drives' because the original mechanisms had much in common with early clocks, which used weights and pendulums to keep time. The Omegon MiniTrack LX2 brings this older technology bang up to date by using a clockwork motor to power a compact equatorial tracking mount that can handle a payload up to 2kg and focal lengths up to 100mm.

Until now, similar ultra-portable tracking mounts have used small electric motors and electronic control circuits to accurately rotate the right ascension (RA) axis. The MiniTrack is, therefore, quite a departure from the well-trodden path. This elegant solution means that an ultra-portable mount can be taken anywhere without having to rely on any power requirements other than a little bit of wrist action every hour or so to gently wind up the clock mechanism. This is, perhaps, the first truly eco-friendly mount.

Such an unusual piece of equipment demanded our attention, so we were keen to give it a run. Its

### SKY SAYS...

More than just a gimmick, this clockwork marvel is a fine tracker

arrival in the summer months was ideal for some wide-field Milky Way imaging with a camera and lens, which is what this mount is designed for rather than a small telescope.

### Ticking all the boxes

The mount weighs in at 464g (774g with the supplied ball-and-socket head installed) and is just 215mm long by 80mm wide at its widest point, making it almost pocketable. The chassis is a single aluminium casting with a black crackle finish and highly polished components. Attached to one end is a quadrant arm with a rubber platform onto which the substantial ball-and-socket head is attached via a 3/8-16 bolt.

If you opt to buy the mount-only version of the MiniTrack you can use your own ball-and-socket head and, if necessary, change the mounting bolt to the 1/4-20 bolt supplied, using the spanner and adaptor included in the kit. A moulded clip at the top of the chassis holds a small plastic sighting tube to assist in polar alignment.

Assembling the system is very quick indeed. You start by attaching the MiniTrack to your own tripod's pan-and-tilt head or precision altaz head so ▶

## A timer with teeth

For accurate tracking on an equatorial mount, the larger the diameter of the final gear in the drive chain, the better. However, this would be at odds with the goal of portability. Using a quadrant arm has the advantage of using an apparently large drive gear in a small physical size as only a small part of the perimeter of the 'complete' gear is required. In the case of the MiniTrack, the arm represents a section of a gear that would have a diameter of 290mm.

Although quadrant arms have been used in other designs before, what makes this product so unusual is the clockwork motor that drives the arm. The motor used in this design is essentially a one-hour timer installed at one end of the body. It even pings at the end of the run to alert you to the fact that the hour is up. The clockwork motor engages with a series of intermediary gears that ultimately move the quadrant arm via a set of teeth on its curved outer edge.



## Ball-and-socket head

There is no declination axis on this type of mount so the camera and lens have to be attached to a ball-and-socket head so that they can point to anywhere in the sky. The beautifully engineered Omegon ball-and-socket head supplied as part of the MiniTrack kit makes pointing at celestial objects very straightforward.

## Miniature saddle clamp

The ball-and-socket head has a well-designed saddle clamp with a single, very positive-feeling hand bolt. This saddle clamps a mini-dovetail bar forming an excellent quick release mechanism for easy attachment and removal. Two discrete detents that slot into grooves stop the bar from falling out by accident.



## 1/4-inch tripod mount

The rear of the mount has a standard 1/4-20, UNC-threaded mounting hole right in the centre of the casting. This allows the MiniTrack to be attached to a wide range of tripod heads and equatorial wedges. We used a Manfrotto 410 geared head to attach the mount, allowing simple adjustment of altitude.

## Counterbalance spring

It's not always possible to achieve perfect balance with a camera and lens and there is no counterbalance shaft with weights in this tracker's design. Instead, a seven-level spring tensioner is built into the mounting head to help alleviate any off-balance pressure being applied to the clockwork drive mechanism.

# FIRST LIGHT

## SKY SAYS...

Now add these:

1. Omegon Titania 600 tripod
2. Omegon 3-way-panheads Pro PD80 tripod pan-head
3. Omegon star chart planisphere

► that you can tilt the tracker to polar align it. You then attach the ball-and-socket head to the mounting platform. Finally, you attach the camera and lens to the quick release dovetail bar.

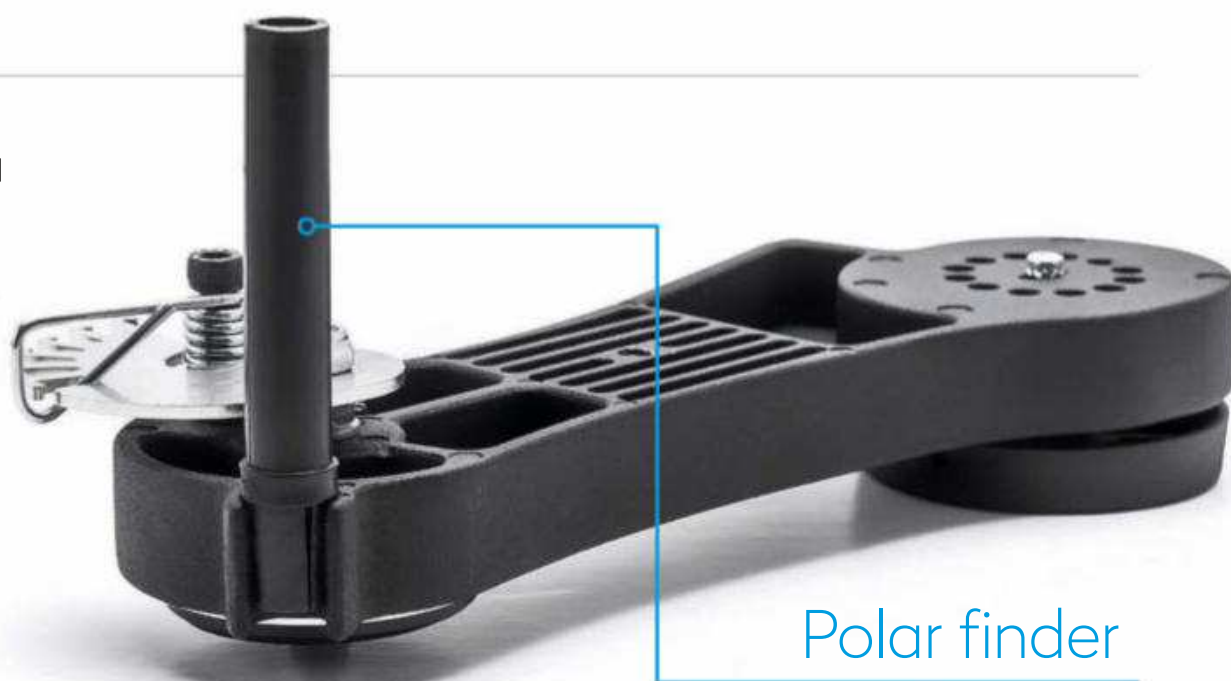
Next up is polar alignment, which you carry out by sighting Polaris through the polar finder tube then locking the tripod's head firmly in position. This alignment process was

a little subjective but for wide-angle imaging it proved to be perfectly

adequate. It should be noted, though, that the MiniTrack will only track the night sky in the northern hemisphere.

Once the mount is correctly polar aligned you then attach the camera to the ball-and-socket head using the dovetail clamp, which we easily managed to achieve even in the dark.

To start the imaging session, you turn the large disc at the foot of the mount a maximum of one rotation to wind up the clockwork motor – it's as simple as that. Once the motor's running, you can loosen the ball-and-socket head to allow the camera lens to point to the celestial



Polar finder

object you want to photograph and, after focussing, image capturing can begin.

We used an external intervalometer attached to our Canon 450D and 28mm wide-angle lens set to capture a continuous set of three-minute exposures with the camera in 'bulb' mode. We used our own hot shoe-mounted red dot finder to aim the lens in the general direction of the bright star Sadr (Gamma (γ) Cygni) in Cygnus, and captured images until the motor ran out, which was exactly an hour later.

The resulting star shapes were impressive, showing no sign of trailing even though we were using the maximum exposure length recommended for our camera and lens combination.

We would recommend the MiniTrack to users of any experience level as a simple means of mounting basic imaging equipment for wide-field imaging. **S**

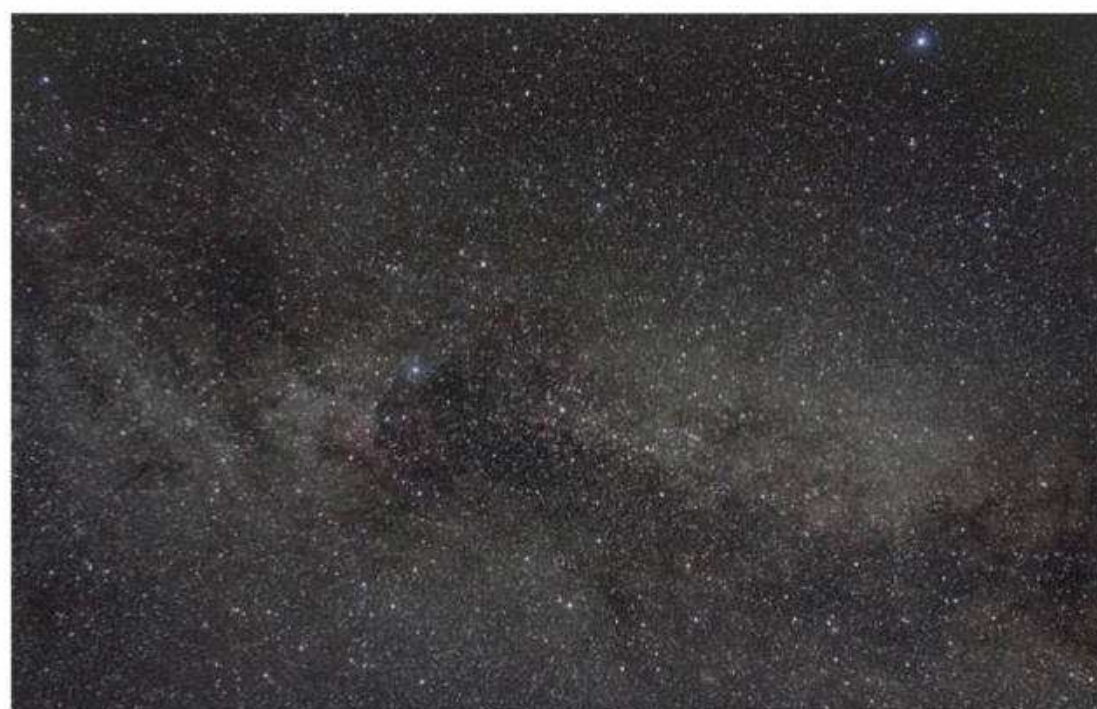
Equatorial mounts require polar alignment to avoid star trails and field rotation during long exposures. The MiniTrack is supplied with a very simple polar finder comprising an 8mm sighting tube that fits into a clip on the end of the drive unit. Visually aligning with Polaris through this tube achieves an approximate polar alignment, which works well enough.

▼ Cropped close-up of Cygnus showing round stars near Sadr



## Verdict

Assembly	★★★★★
Build and design	★★★★★
Ease of use	★★★★★
Features	★★★★★
Tracking accuracy	★★★★★
OVERALL	★★★★★



▲ Cygnus taken with a Canon 450D with 28mm wide-angle lens using 19x3 minute exposures stacked. The edges show some slight distortion, but this is due to the lens and not related to the MiniTrack's capabilities

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# FIRST LIGHT

See an interactive 360° model of this camera at [www.skyatnightmagazine.com/ASI294MC](http://www.skyatnightmagazine.com/ASI294MC)



## ZWO ASI294MC Pro camera

WORDS: GARY PALMER

It may look much like many other ZWO cameras, but it's hiding some surprises

### VITAL STATS

- **Price** £1,026
- **Sensor** Sony IMX294
- **Sensor size** 19.1x13.0mm
- **Resolution** 11.7MP (4,144x2,822MP)
- **Exposure** 32us-2,000s
- **Max FPS at full resolution** 19fps
- **Weight** 0.80kg
- **Extras** 1.8m USB3 cable; 1.25-inch nose piece; cover and adaptor; padded bag; CD with imaging software
- **Supplier** 365 Astronomy
- **Tel** 020 3384 5187
- **www** 365astronomy.com

**O**n the outside the ASI294MC Pro colour cooled camera doesn't appear to bring much new to the company's range, with its familiar styling, USB 2 hub and high-speed USB 3 port. But it's on the inside that the camera starts to become much more interesting and exciting.

This is the first camera in the world to boast Sony's new IMX294 CJK back-illuminated 3/4-inch sensor, with a diagonal size of 23.2mm and approximately 11.71MP. Being part of the Pro range, the camera comes with 256MB DDR3 (double data rate type three) memory installed and a two-stage TEC cooling system that will cool it to between -35°C and -45°C below ambient temperature. You'll need a good power supply for the camera to reach this range, though, because a power supply unit under 3A can cause software to disconnect when you're capturing images.

HGC is a new feature with this camera and stands for high gain conversion. It switches on automatically when the camera's gain is raised above 120. This reduces read noise to a lower level at higher gain without a loss to the dynamic range. ZWO claims this means the camera can capture 4K

### SKY SAYS...

A powerful CMOS sensor that's especially impressive for live capture and live stacking

images, although in our experience 4K would probably be more suited to industrial applications than astronomy.

While we had a lot of warm weather over the review period, they weren't the clearest seeing conditions, with lots of high cloud. As the Moon was also bright we set up for some imaging in the early evening and it soon became apparent that we needed to play with

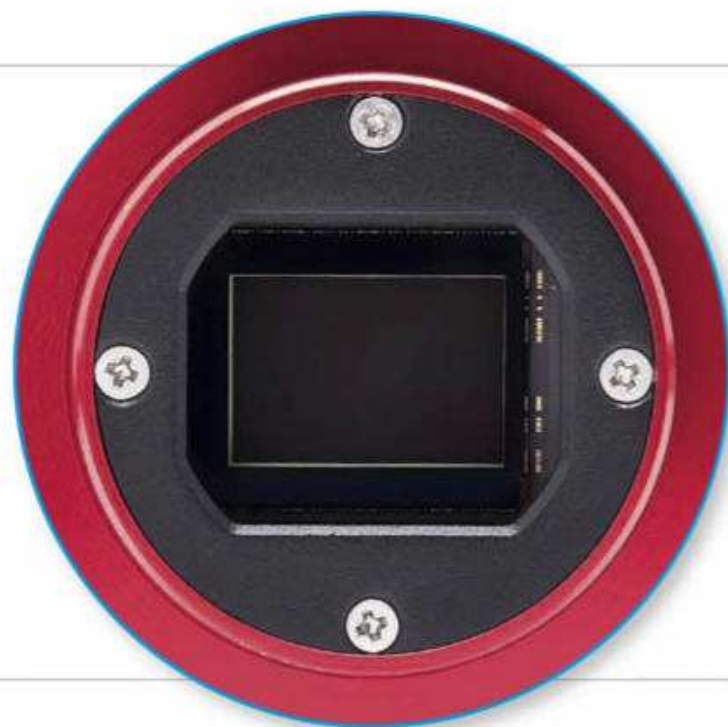
the camera's settings. The initial onscreen view was very blue. On checking, the blue level was starting at 90 instead of around 55. We contacted the manufacturer and they were helpful in solving the problem. It seems it was a software glitch.

### Picking out the finer details

Once sorted, the camera produced a fine image on screen and capturing was very easy using the SER file capture mode. While not the fastest camera in full resolution we only needed to capture around 200 frames and stack 50 to produce a decent image of the Moon. Switching over to planetary capture a few nights later, the camera performed well under the poor conditions and low views we had this season. Running in Region Of Interest (ROI) mode on Saturn we were able to capture some good ▶

## The sensor

The IMX294 is a 4/3-inch, back-illuminated sensor with a diagonal size of 23.2mm and a resolution of 4,144x2,822. In 14-bit mode the camera will run at around 16fps at full resolution and up to 25fps in 10-bit mode. When the camera is used in ROI mode, the frame rate can run up to 120fps. HGC (high gain conversion) mode switches on when the gain goes over 120 and this helps to keep the dynamic range constant. The 63700e full well capacity (the amount of charge an individual pixel can hold before saturating) is three times that of an ASI 1600 camera's, making it very sensitive and ideal for electronically assisted astronomy (EAA), live stacking and live displays at outreach events. What this really helps with is cutting down the saturation of stars even when capturing long exposures, which has been a problem with some CMOS sensors in the past.



## Accessories

The ZWO ASI294MC comes with an extensive array of accessories making it easy for the user to connect to other equipment. This includes a 1.8m USB 3 cable, a CD-ROM with two software applications (FireCapture and SharpCap), as well as a 1.25-inch nose piece, cover and adaptor. There is also a padded bag for camera protection.

## Optical glass

The ASI294MC has a UV/IR cut-off filter as it has a colour sensor. The range for this is between 400-700nm and it helps protect images from stray signals when the camera is used in planetary mode. The sensor chamber is designed as a sealed unit, so it is not advisable to remove the optical window with this design of camera.

## DDR memory buffer

Included with the camera is a 256MB DDR3 memory buffer, which helps with reliably transferring data. DDR3 has the added benefit of reducing amp glow caused by slow transfer speeds when the camera is used with a USB 2 port. It also helps with a stable connection when running the camera on extended USB leads.



# FIRST LIGHT

## USB 3 port & USB 2 hub

The camera has a USB 3 port enabling it to support between 16-19fps (dependent on mode) at full resolutions. The ASI294MC also sports a USB 2 hub allowing the user to connect an array of accessories, such as filter wheels and guide cameras. The camera comes supplied with an additional two 0.5m USB 2 cables.

## Two-stage cooling

The Pro version of the ZWO ASI294MC has a built-in two-stage TEC cooler which allows temperatures to be regulated within the capture software to  $-35^{\circ}$  to  $-45^{\circ}\text{C}$  below ambient. The cooler requires a 12V power supply, which is not currently supplied and is an extra add-on item.



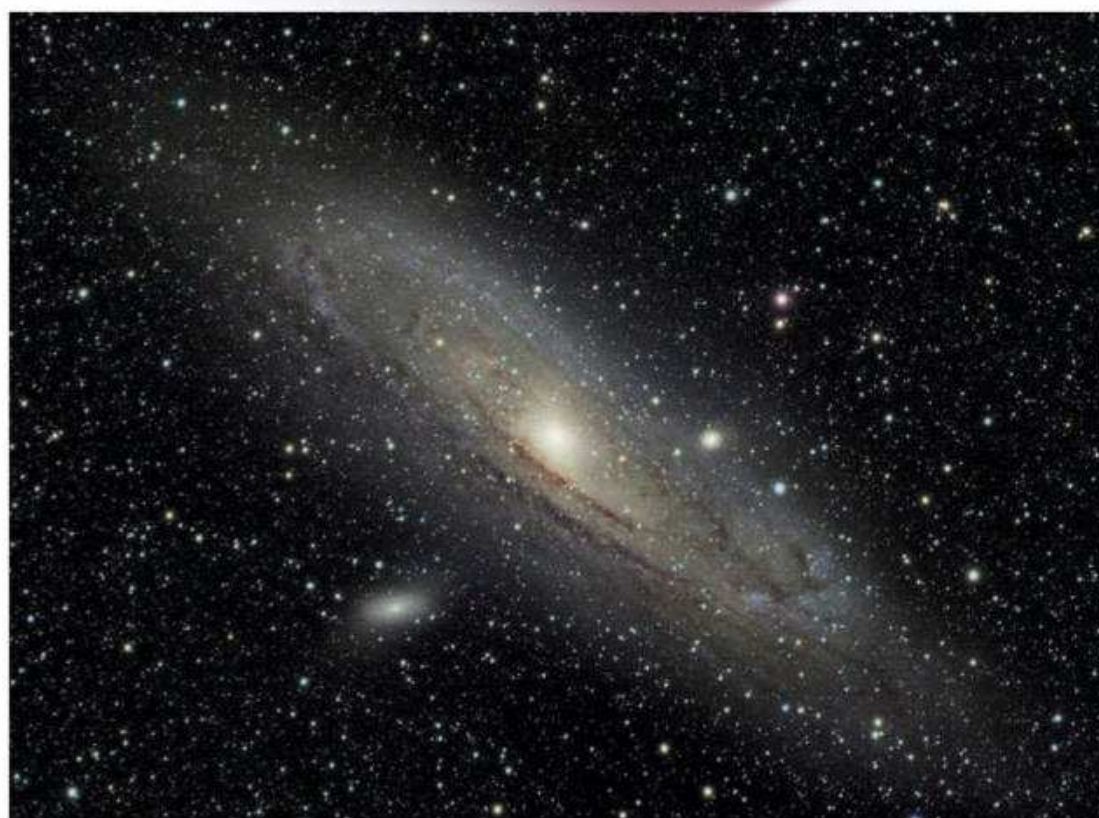
▲ M27: 60"x60"  
Processed in PixInsight  
and Photoshop

► Mars: 5,000 frames  
captured, 500 frames  
stacked in AS2 with  
processing in Photoshop



► detail with the use of an atmospheric dispersion corrector on a 4-inch, f/11 telescope. The next target was Mars and, to be honest, we were not expecting to capture any surface detail because of the dust storm that was enveloping the planet. Using the same telescope with the addition of a 4x Powermate we set ROI capture to 640x480. In this mode the camera was recording at around 100fps. The results were especially impressive because we processed images from a few cameras that week, and the ASI294MC was the only one that picked up any surface detail on Mars.

On the next clear night, we used the camera coupled with a 2.5-inch quad refractor to image M31, the Andromeda Galaxy, and look at some live views of targets. To achieve this, we set the camera up in USB 2 mode with a 7m USB extension lead. The camera was very stable, dropping no frames in the capture software, while using a short capture time of 60 seconds meant we didn't need to autoguide.



▲ M31: 111x60". Processed in PixInsight and Photoshop

The camera is great for live capture and live stacking of objects, and it was a pleasure to watch a comet cross the screen in real time. This would be ideal for outreach events for showing objects to the public, or for live stacking in capture software.

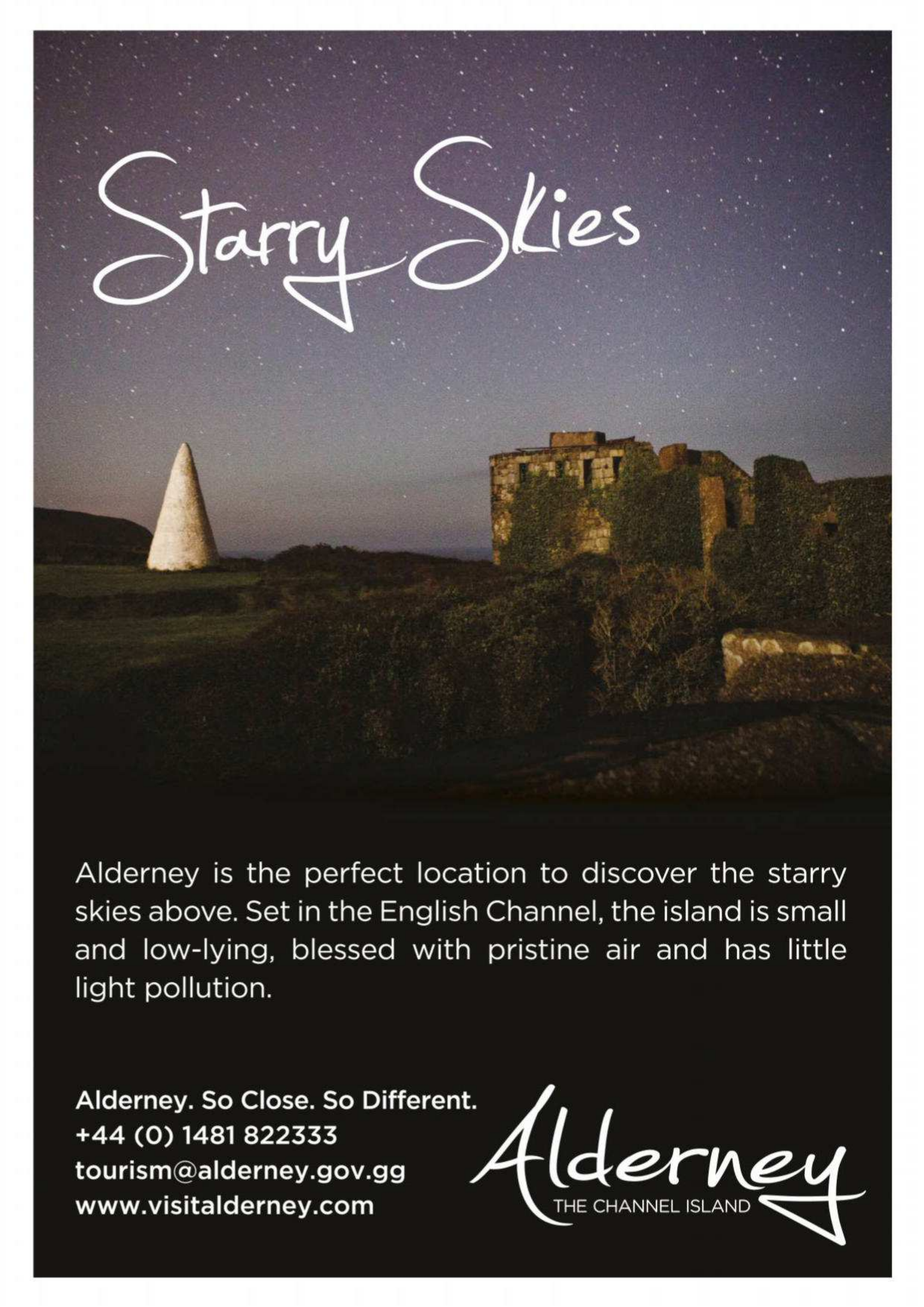
The ZWO 294 MC Pro camera really has something for everyone and with CMOS sensor boundaries being pushed with each new model of camera that comes out, it makes us wonder what new developments will be coming next. **S**

## Verdict

Build and design	★★★★★
Connectivity	★★★★★
Ease of use	★★★★★
Features	★★★★★
Imaging quality	★★★★★
OVERALL	★★★★★

### SKY SAYS... Now add these:

1. ZWO 12V 5A AC to DC adaptor PSU for ZWO ASI cooled cameras
2. ZWO ADC atmospheric dispersion corrector
3. ZWO Infrared cut-off filter (1.25-inch or 2-inch)



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# Books

New astronomy and space titles reviewed

## RATINGS

★★★★★ Outstanding

★★★★☆ Good

★★★☆☆ Average

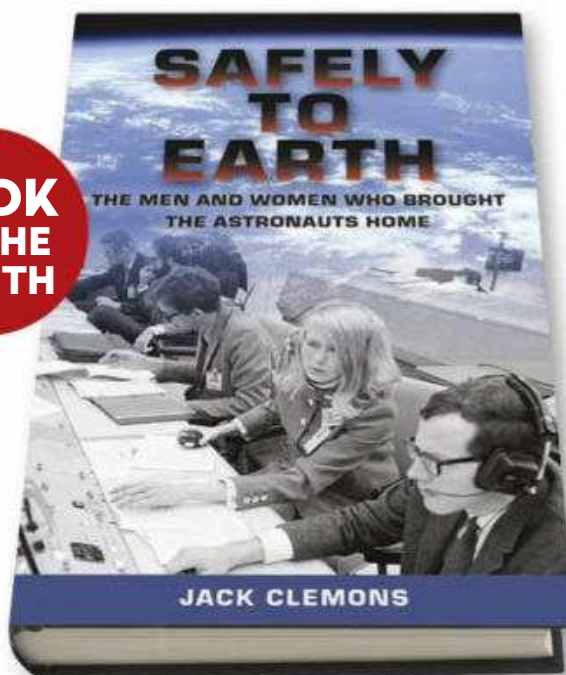
★★☆☆☆ Poor

★☆☆☆☆ Avoid

## Safely to Earth

Jack Clemons  
University Press of Florida  
£21.50 • HB

BOOK  
OF THE  
MONTH



Jack Clemons began work as part of the engineering team that supported NASA space missions in 1968, three days after the launch of Apollo 8, the first manned spacecraft to orbit the Moon. He was tasked with developing, writing and testing computer software to control the Command Modules' re-entry through Earth's atmosphere. At the time, this was done using a slide-rule, as the first hand-held calculator wasn't available until 1972 and cost the best part of £2,000. Computer programs were handwritten in the computer language FORTRAN and typed onto cards in a punch card machine (one line of program per card).

Clemons' memoir follows the ground teams through all the subsequent Apollo missions, including a detailed account of the Apollo 13 rescue, as well as the Skylab and Space Shuttle missions, up to the mid-1980s, and from the ridiculously primitive Display and Keyboard (DSKY) device on the Apollo Command Modules to the five flight computers aboard the Space Shuttle.

The team needed to anticipate every eventuality, calculating all the variables such as changes in geographic location and angle of re-entry. Even the time of year and the weather had to be taken into account, with alternative back-up plans in place.

The margins for error were tiny. In computer programming, the industry average is 10-12 errors for every 1,000 lines of code. Over the 30-year Space Shuttle

programme, the error rate for computer code developed by IBM for the Onboard Flight Software went from 0.8 errors per 1,000 down to less than 1 error per 5,000 lines of code. That is closer to error free than any large complex software system before or since.

The book has a very nice appendix covering frequently asked questions about Apollo and the Space Shuttle, which includes some interesting assessments of both the Space Shuttle Challenger and Space Shuttle Columbia disasters.

This book is not just for computer geeks. If you have seen (and loved as much as I did) Ron Howard's 1995 film *Apollo 13*, then you will love this insider's tale of human space exploration from the point of view of the team back on planet Earth. Why should the astronauts get all the glory?

★★★★★

JENNY WINDER is a freelance science writer, astronomer and broadcaster



Tense times at mission control during the ill-fated Apollo 13 mission

## TWO MINUTES WITH Jack Clemons



What are your most memorable moments from the Apollo era?

Being in a NASA Mission Control support room during

Apollo 11 and 13. My speciality was atmospheric re-entry and both had unexpected changes I could help with. Apollo 11 moved its splashdown location late in the mission because of some nasty Pacific weather and Apollo 13's return to Earth was unlike anything we'd planned.

What effect, in your opinion, did the retirement of the Shuttle have on the staff working at NASA at the time?

I'd moved on before the last Shuttle launch in 2011, but my colleagues on that programme were disheartened. An era of US leadership in human spaceflight had ended. We're no longer able to launch our own astronauts into space. The greater loss is that those professionals who knew how to get us back into orbit have moved on or retired – a resource no amount of new funding can recover.

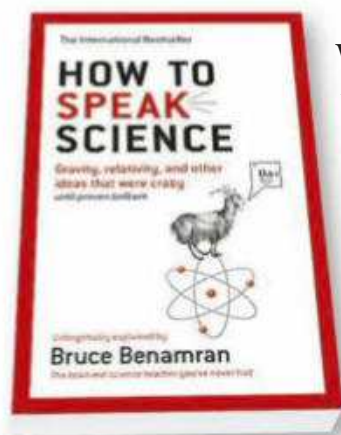
What are your thoughts on NASA working with Space X and Boeing?

I'm in favour. NASA's role was to develop the new technologies required to put humans into orbit around Earth and on the Moon. Private enterprise wouldn't have had the expertise, financial resources or business motivation to undertake those tasks. Now NASA has made that investment, so the future of near-Earth human spaceflight is, as it should be, in the hands of private industry. And maybe they'll even get us back to the Moon.

Aerospace expert JACK CLEMONS was a lead engineer on NASA's Apollo and Space Shuttle programmes

# How to Speak Science

Bruce Benamran  
Virgin Books  
£12.99 • PB



When I picked up *How to Speak Science* I assumed it was going to explain how to use scientific language in some way, or perhaps how to understand scientific concepts, written in a way a complete beginner

could understand. What I found was something a little different.

At first glance the book's contents seem both impressive and daunting, covering a wide range of topics from matter, light and the Solar System to quantum mechanics and general relativity. In parts it strays more towards the history of science, with lots of discussion about the people involved and the sequences of events.

The author has a fairly light-hearted conversational style, replete with asides

and tangential comments. That can make the book a little hard to follow at times, but it is possible if you pay attention. A number of the asides are useful little analogies, some of which are as fascinating as the concepts themselves. After all, when reading about our understanding of light you don't necessarily expect to find yourself reading about the structure of the eye, airline security and pirates, or about the sixth (let alone ninth) sense!

There are a fair few attempts at humour scattered throughout, including some running jokes, though they tend to be aimed at a US audience (I'm not sure how many UK readers will be familiar with *People Magazine*, but maybe that's just me).

Overall *How to Speak Science* is an enjoyable read, though the numerous asides and distractions might make it hard to follow for those coming to the subject completely fresh. Because, despite the book's title, it probably helps to have a little understanding of physics before you embark on reading it.

★★★★★

DR CHRIS NORTH is Ogden Science Lecturer and STFC Public Engagement Fellow at Cardiff University

# The Sky at Night Book of the Moon

Maggie Aderin-Pocock  
BBC Books  
£9.99 • HB



Are you a 'lunatic'? *The Sky at Night* co-host Dr Maggie Aderin-Pocock admits to being one since early childhood and her new book

promises to "bring out the inner lunatic that lies within all of us".

Next year is the 50th anniversary of humankind's first steps on the lunar surface. This book provides a timely and delightful journey into the Moon's wonders, plus a look at its physical, geological and cultural impact on Earth, and how the future of Earth and its satellite are tied together.

Aderin-Pocock has imbued the prose with her obvious passion and warmth for Earth's nearest neighbour. While the book is packed with facts and science, it is her personal stories that punctuate the narrative and convey an infectious enthusiasm.

She looks at the Moon from all angles, from its place in our prehistory (one of the oldest known lunar calendars is a 50km series of 12 pits in Scotland dating back to 10,000BC) to its role in art and poetry.

Having sold us the Moon, she then deals with the practical: how to observe the Moon with the naked eye and with equipment. This section is accessible and easy for beginners, complete with basic lunar maps.

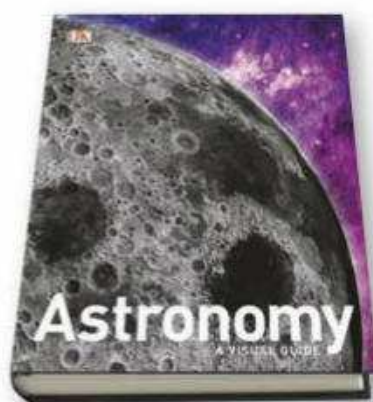
But, as she highlights, our future with the Moon is yet unclear. Will we one day live in lunar bases? Or is Mars more in favour? And, as the last astronaut to walk on the Moon in 1972, the late Gene Cernan, once asked: "When are we going back?"

★★★★★

SHAONI BHATTACHARYA is a science writer and journalist

# Astronomy: A Visual Guide

Ian Ridpath (consultant editor)  
DK  
£20 • HB



Astronomy. It's hard to know where to start, but most guides go one of two ways: either with stargazing, or with the birth of astronomy in the Middle East around 2,500 BC.

Prolific astronomy writer Ian Ridpath opts for the latter approach but doesn't completely forget about the stargazing side of things. I can imagine that for anyone starting out in astronomy the prospect of having to learn about the work of Nicolaus Copernicus, Tycho Brahe and Galileo Galilei would be as daunting as a sky full of unknown stars, but Ridpath's writing is sharp, succinct and constantly engaging.

It's also brilliantly illustrated. In structure and layout the book is similar to an atlas of world history: there are images, illustrations and plenty of excellent

diagrams, all presented in a high quality, hardback slip cover. It would make a great Christmas present.

The usual topics (in chapters such as 'The Big Bang', 'The Moon' and 'Starting Observing') are all given a double-page spread, sometimes two. After the history section is an impressive treatment of the Universe, while the section entitled 'The Night Sky' delves into observing. If I have a criticism, it's that 'The Night Sky' section rushes into the need for equipment right from the off, and fills up the latter third of the book with month-by-month star charts and almanac information. Some of that seems rather old-fashioned in this era of smartphone apps.

Indeed, so too would the very concept of a reference book, if it weren't for exquisite production qualities and writing. Together, they lend this colourful encyclopaedic effort a thoroughly accessible feel.

★★★★★

JAMIE CARTER is the author of *A Stargazing Program For Beginners: A Pocket Field Guide*

# Gear

Elizabeth Pearson rounds up the latest astronomical accessories



1

## 1 Celestron NexYZ 3-axis smartphone adaptor

Price £49 • Supplier Tring Astronomy Centre  
01442 822997 • [www.tringastro.co.uk](http://www.tringastro.co.uk)

Take smartphone images through your eyepiece using this adaptor. The model has a high build quality and is centred around the optical axis to reduce shakes during long exposures.

## 2 Stargazer notebook

Price £6 • Supplier Eclectic Eccentricity  
[eclecticeccentricity.bigcartel.com](http://eclecticeccentricity.bigcartel.com)

Need a new log book? Or something on which to jot down your observing notes? Then this A5, lined notebook is on theme. Made from 100 per cent recycled paper.

## 3 Celestron Elements ThermoTorch 5

Price £47 • Supplier Wilkinson Cameras  
01772 252188 • [www.wilkinson.co.uk](http://www.wilkinson.co.uk)

ThermoTorch 5 combines a torch to help you get to your observing site and a handwarmer to keep you toasty on the way. You can even use it as a power bank to top up your phone.

## 4 Daystar universal solar filters

Price £14 • Supplier 365 Astronomy  
020 3384 5187 • [www.365astronomy.com](http://www.365astronomy.com)

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## 5 Celestial chart tote bag

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01189 588586 • [www.presentindicative.com](http://www.presentindicative.com)

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## 6 Swarovski universal binocular tripod adaptor

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01444 237070 • [www.parkcameras.com](http://www.parkcameras.com)

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4



5



6



2



3

FROM THE  
MAKERS OF **BBC** Sky at Night  
MAGAZINE



# THE APOLLO STORY

BBC Sky at Night Magazine brings you *The Apollo Story* – your complete guide to the greatest journey in human history.

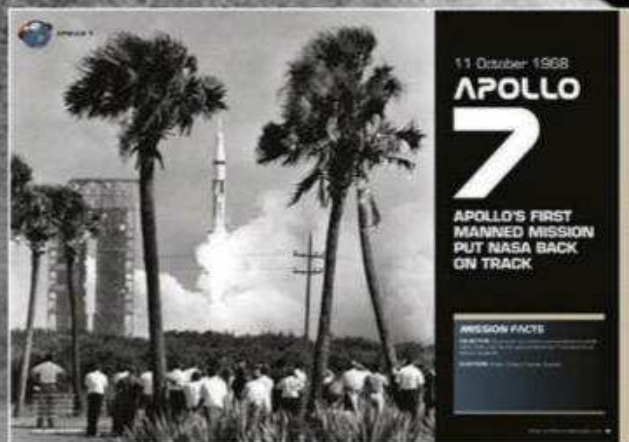
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*Chris*

Chris Bramley,  
Editor, *Sky at Night Magazine*



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# WHAT I REALLY WANT TO KNOW IS...

## Can we find slow-orbiting planets around other stars?



**Helen Giles** is employing a new technique to quickly discover hard-to-spot worlds that take many years to orbit their stars

INTERVIEWED BY PAUL SUTHERLAND

**M**ost of the thousands of exoplanets discovered in recent years have been hot Jupiters. The reason for this is not because they are more common but because they are much easier to find and quicker to confirm.

Most exoplanets have been found using the transit method, where they pass in front of the star, producing a measurable dip in the brightness of the starlight. Massive planets in rapid orbits produce more noticeable dips thanks to their sheer size.

NASA's Kepler space telescope also helped us find a number of planets with longer orbital periods, but that was simply because Kepler observed stars for four years during its initial mission. Otherwise, these slower-moving planets have so far mostly been discovered using radial velocity, where a ground-based spectroscopy instrument measures the wobble in a star's light. Astronomers have been conducting searches with radial velocity a lot longer than we've been doing transit photometry.

### The eye of the beholder

Computer algorithms are used to detect signals in Kepler data that indicate the existence of an exoplanet. I found that applying human judgement allowed me to find a candidate for an exoplanet quite unlike the majority of discoveries, which had the longest period of any planet spotted by Kepler.

My discovery came about when I was scanning the data from K2 (the follow-up mission from Kepler) trying to find any sort of exoplanet – I didn't really mind what kind of planet or what its period was. The computer code ranks potential exoplanet candidates from the best looking to the worst, and I checked every single one by eye. This planet stuck out like a sore thumb.

It was ranked very low among the possibilities, since only one potential transit had been observed by K2. But as soon as I applied my human eye to look at the data, I saw a beautifully-shaped dip in

the star's light-curve and thought, "Okay, that looks interesting, let's investigate further."

Transits of most detected exoplanets typically last between two to 16 hours, and it is standard

practice to observe at least three passes

before the exoplanet is confirmed. My exoplanet's transit lasted 54 hours

– almost two and a half days. Having to wait three orbits to confirm it would take over 30 years at that rate. So instead my team at the University of Geneva used other observations of the star to learn more about it and its potential planet.

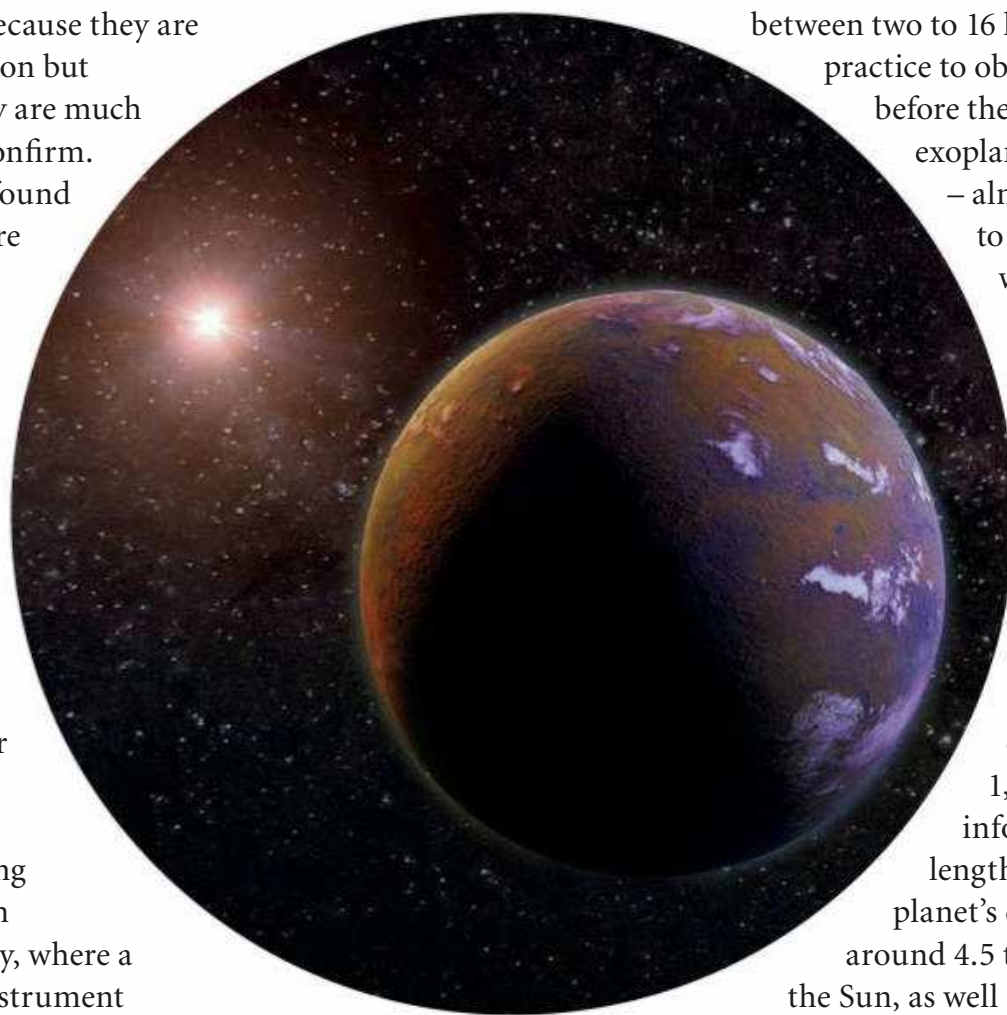
The parent star is known by its catalogue number EPIC248847494. We first used recently released data from ESA's Gaia mission to determine that it lies about 1,500 lightyears from us. That information, together with the length of the transit, told us that the planet's distance from its star must be around 4.5 times that of the Earth from the Sun, as well as the length of its 'year'.

Importantly, we needed to check that this orbiting object was a planet and not another star. We turned to the Swiss 1.2m Leonhard Euler Telescope at La Silla in Chile to measure the star's radial velocity, or, more simply, its wobble. This showed that the newly discovered companion is less than 13 times as massive as Jupiter, so too small to be a star.

Officially this discovery is still just a great candidate for an exoplanet, but a very convincing one! To get confirmation using radial velocity will take a full orbit of 10 years, though we should get some estimation in around half that time.

This demonstrates a useful technique for finding more slow-orbiting exoplanets. Some might already lurk in archived data; finding them would be a good citizen science project. But the main focus will be on future data collected by the likes of NASA's Transiting Exoplanet Survey Satellite (TESS), which launched in April. TESS will only observe each bit of sky for 27 days, so it should detect a lot of single transits.

We look forward to discovering many more exoplanets. In theory, we could detect a planet as small as Earth, if its star is fairly stable and bright. **S**



**We could be discovering more exoplanets that aren't hot Jupiters thanks to a new technique that requires a human touch**

**ABOUT HELEN GILES**  
Helen Giles is a fourth year PhD student at the University of Geneva's Department of Astronomy, where she hunts for exoplanets hidden in the light-curves of distant stars

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All prices correct at time of press. Subject to change. Errors and omissions excepted.



# THE SOUTHERN HEMISPHERE IN OCTOBER

With Glenn Dawes

## WHEN TO USE THIS CHART

**1 OCT AT 24:00 AEST (14.00 UT)**  
**15 OCT AT 24:00 AEDT (13.00 UT)**  
**30 OCT AT 23:00 AEDT (12.00 UT)**

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

## OCTOBER HIGHLIGHTS

Periodic Comet 21P/Giacobini-Zinner appeared over the northern horizon in September, heading south. It starts October rising just before midnight, spending most of the month in Canis Major. It's currently about 0.5AU from Earth and around 8th magnitude. In the morning, keep an eye out for the Southern Taurid meteor shower which usually peaks around 10 October, this year ideally close to New Moon. These meteors are typically bright, slow moving and sometimes produce colourful fireballs.

## STARS AND CONSTELLATIONS

Piscis Austrinus, the Southern Fish, has mag. +1.2 Fomalhaut for a mouth but its body is all 4th magnitude stars. Adjacent Grus, the Crane, is made of brighter stars, but is too far south for traditional legends. It didn't go completely unnoticed; the Arabs merged the fish with part of Grus to form the defunct Southern Whale. Two stars retain their whale-derived names: Al Dhanab (Gamma ( $\gamma$ ) Gruis) which means 'Tail' and Alnair (Alpha ( $\alpha$ ) Gruis) which means 'Bright one in the tail'.

## THE PLANETS

Early in October, Venus is close to the western horizon with Jupiter directly above, around the end of twilight. Saturn is higher again, not setting until midnight. There is no hurry to catch Mars or Neptune, with both planets visible

until the morning. Uranus is near opposition and rising around sunset. There's a chance to see seven planets at once but you'll need to observe in twilight. Mercury reappears in the evening of 16 October, passing Venus just as it becomes a twilight-only object.

## DEEP-SKY OBJECTS

This month a trip to the winged horse, Pegasus. Pi ( $\pi$ ) Pegasi (RA 22h 09.6m, Dec. +33° 08') is a great binocular double star with components of mag. +2.3 and +5.6, a comfortable 9.5 arcminutes apart. Pi<sup>1</sup> is itself multiple, surrounded by four stars of mag. +10.1, +10.6, +11.9 and +12.5 with distances ranging from 30 to 120 arcseconds from their bright (mag. +5.6) primary.

Pegasus is not renowned for bright galaxies but there's an exception! Look 5.7° east-northeast of Pi Pegasi to NGC 7331 (RA 22h 37.1m, Dec. +34° 25'). This near edge-on, mag. +9.5 spiral galaxy has a bright core and stellar nucleus. Its halo is clearly visible through large telescopes, as long as 10 arcminutes. Even though it's low (around 20° altitude) from mid-latitude Australia, NGC 7331 is still an impressive sight.



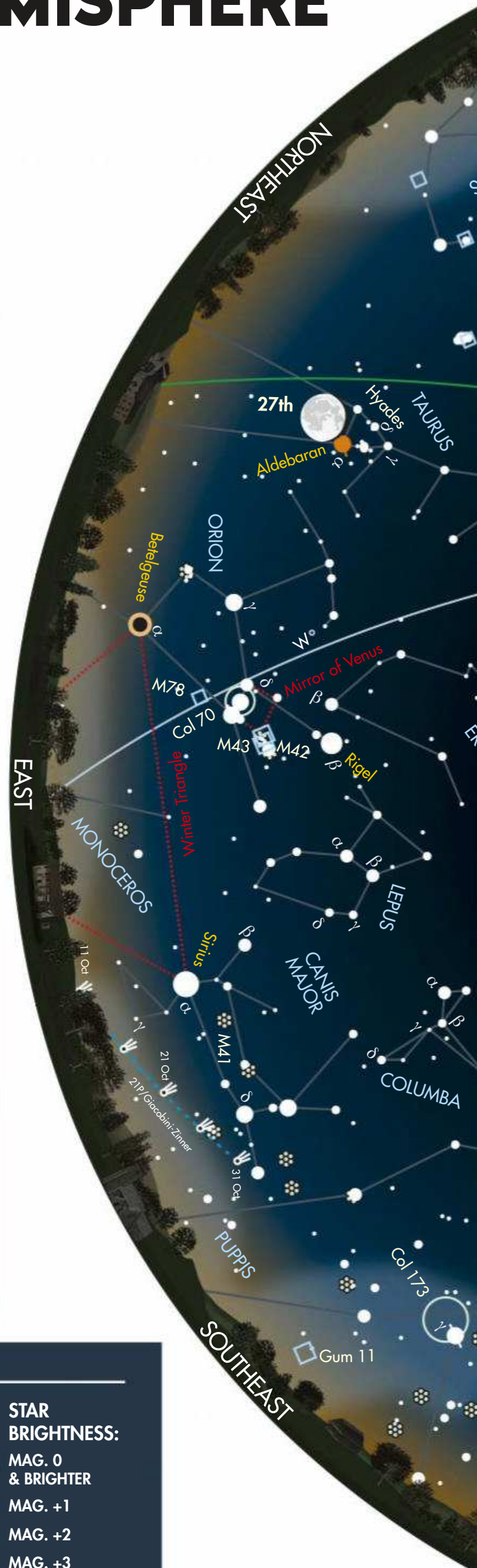
## CHART KEY

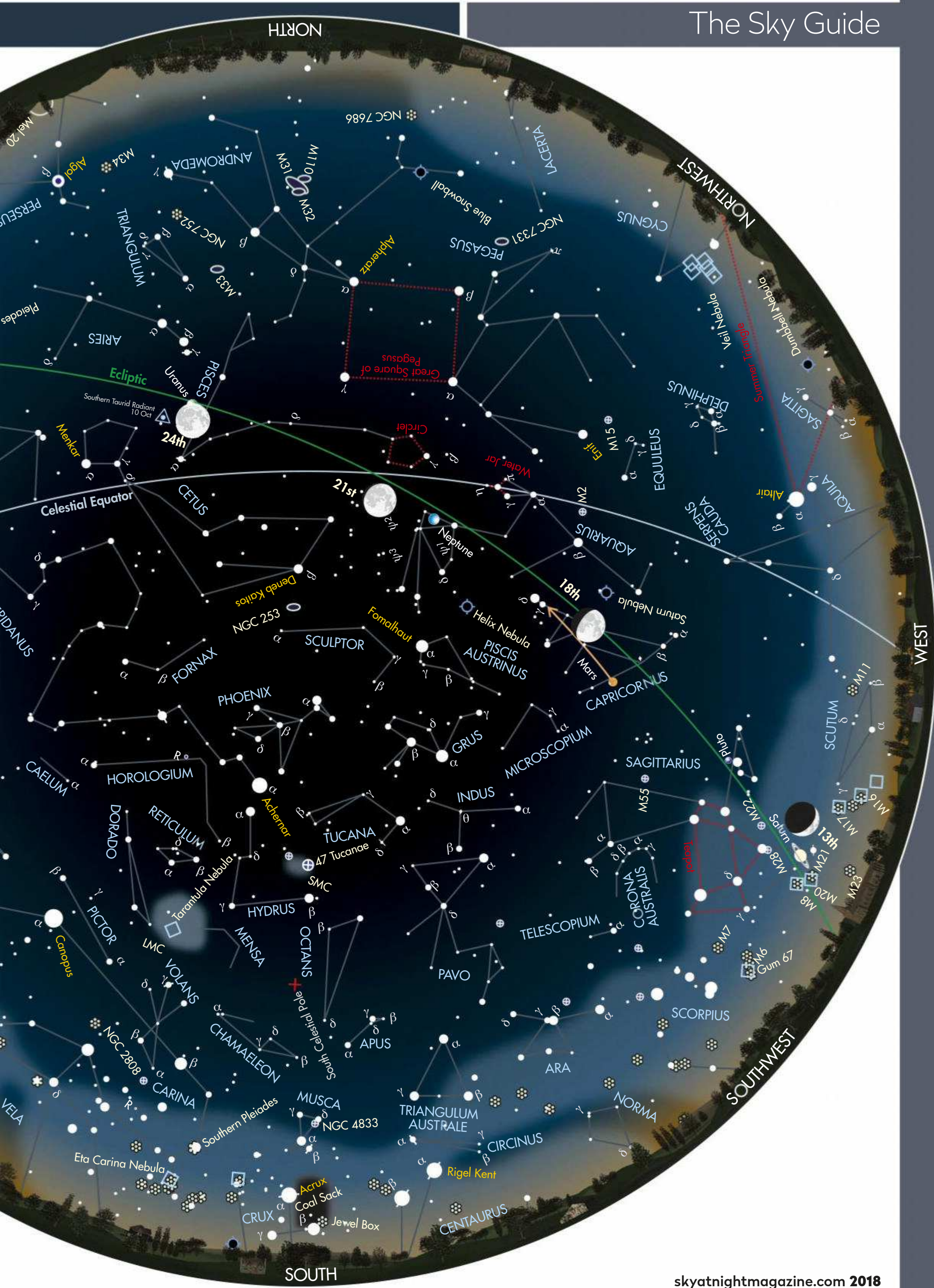
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA

- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK

- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

- STAR BRIGHTNESS:**
- MAG. 0 & BRIGHTER
  - MAG. +1
  - MAG. +2
  - MAG. +3
  - MAG. +4 & FAINTER





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